Analysis Of Design Of Online Animations In Biochemistry Using A Framework Based On Multimedia Learning Principles

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Abstract: Background: MBBS 1st year students access online animations in Biochemistry which in turn helps them understand the rationale behind diagnosis and management of diseases. However, there is a paucity of studies that have analysed online animations in Biochemistry based on Mayer's Multimedia learning principles. Our objective was to analyse the design of free online animations in Biochemistry using a framework based on Multimedia Learning Principles that reduce extraneous processing. Material And Methods: In this cross-sectional study, design of 102 online Biochemistry animations was analysed using a framework based on Multimedia learning principles that reduce extraneous processing, and Focus Index (FI) score was calculated. Result: 41.2 % of the animations had a FI score of less than 5, suggesting that these animations do not comply with all Multimedia learning principles. Animations violated individual principles in the range of 11 -17%. Conclusion: Significant proportion (41.2%) of online Biochemistry animations do not comply with all the Multimedia learning principles, suggesting that users of these animations may be distracted by extraneous content in the animations leading to poor learning outcomes. Multimedia learning principles should be incorporated while designing animations to enhance their potential as learning aids for MBBS students. [Ravi Kishore P Natl J Integr Res Med, 2021; 12(6): 59-63]

Key Words: Biochemistry Animations, Mayer's Principles, Medical Students

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Introduction: MBBS 1st year students learn complex molecular concepts in Biochemistry that helps them understand the scientific basis underlying the diagnosis and management of diseases[1]. Animations on Biochemistry topics can be freely accessed through popular search engines like www.google.com and www.youtube.com. MBBS 1st year students access online animations in Biochemistry to learn complex concepts[2]. Based on Cognitive Theory of Multimedia Learning, Richard E Mayer proposed multimedia learning principles that could be used to design animations to maximise learning[3]. Animations that incorporate Multimedia learning principles in their design have been shown to provide better learning outcomes when compared to graphics[4]. There is a paucity of evidence regarding the potential of online animations in Biochemistry as visual learning aids.

Our objective in this study was to analyse the design of free online animations in Biochemistry using a framework based on Multimedia Learning Principles that reduce extraneous processing, to determine their potential as effective learning aids for MBBS 1st year students.

Material & Methods: This is a cross-sectional study for analyzing online animations related to Biochemistry topics. Ethical approval was not needed for this study for two reasons-First, human subjects were not included in this study; second, 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 1st year syllabus as prescribed by National Medical Commission (NMC) of India in the year 2019 was reviewed and 27 Biochemistry topics were chosen[1]. Animations related to these topics were searched on search engines www. google.com and www.youtube.com using relevant key words.

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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"[5]. Animations were shortlisted based on the following criteria-

Inclusion Criteria: a. Animation should fit the above definition. b. Animation should have content relevant to the topic.

Exclusion Criteria: Animations that require payment or that require user credentials for access.
A total of 102 animations were shortlisted based on the above criteria.

Frame work Based Approach For Analysis Of Online Animations: We used a framework based on Multimedia learning principles to analyse the design of online animations and derived a Focus Index (FI) score, which provides quantitative measure of design quality of animations.

Multimedia Learning Principles: Mayer's multimedia Learning Principles, based on cognitive theory of multimedia learning, are evidence based guidelines that could be incorporated in the design of multimedia like animations. Mayer proposed five principles to manage extraneous processing.

1. Coherence principle states that learning outcomes are better when extraneous words, pictures and sounds are excluded in the multimedia presentation rather than included.

2. Signalling principle states learning outcomes are better when essential words/graphics are highlighted in the multimedia presentation.

3. Redundancy principle states that people learn better when graphics and narration are used in Multimedia presentation rather than graphics and on-screen text.

4. Spatial Contiguity principle states that learning outcomes are better when corresponding words and pictures are presented in proximity rather than far from each other on the page/screen in a multimedia presentation.

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

These principles when incorporated in the design of multimedia presentation like animations have been shown to reduce extraneous processing and contribute to improved learning outcomes[3].

Extraneous Processing: When multimedia presentations like animations are designed, it is possible that many elements are included that may not serve the instructional objectives. These elements may include irrelevant verbal statements, onscreen text or pictures. These constitute extraneous material. Extraneous processing is a type of cognitive processing that does not serve the instructional objective, and it is caused by presence of extraneous material in the animation or due to confusing layout of the presentation.

For instance, if the captions are printed at the bottom of the screen and animation (graphics) is presented above, the learner is compelled to visually switch back and forth between words at the bottom portion of the screen and corresponding part of the graphic (animation).

This visual switching back and forth is a form of extraneous processing because it diverts precious cognitive capacity away from instructional goal due to poorly designed animation. This problem can be resolved by placing the words close to corresponding portion of the graphic.

If extraneous processing takes up all or major portion of the learner's available cognitive capacity, then the learner is not able to utilize the cognitive processes for learning such as selecting, organizing and integrating the presented material. This leads to impaired understanding the concept at deeper level. The result is poorer learning outcomes[3].

The shortlisted animations (n=102) were evaluated using the above Mayer's Multimedia Learning Principles mentioned above. For the signalling principle, we considered only visual cues (in the form of symbols) that highlight essential material. Verbal cues were not included[6].

Focus Index Score: If a principle was complied with in an animation, a score of 1 was given. If a principle was violated, score of 0 was given. Total score for an animation obtained after adding all the scores for individual principles was the observed Focus Index (FI) score for a given animation. Maximum FI score for any given animation is 5.

Rationale And Interpretation Of Focus Index Score: An animation which is appropriately designed consistent with Multimedia learning principles for reducing extraneous processing, has minimal distracting elements enabling learners to focus on essential content leading to

improved learning outcomes. Such an animation would ideally comply with all Multimedia learning principles that reduce extraneous processing and consequently have higher FI scores[3]. So higher FI scores suggest minimal distracting elements, increased focus and better learning outcomes.

Consequently, FI score for an animation gives an easily computable, direct quantitative measure of design quality and is a surrogate measure of potential learning through animations.

Additional aspects of interpretation of FI score are discussed in "Discussion" section.

Statistical Methods: Descriptive statistics was used in the form of proportion and range was used.

Results: Majority (59.8%) of the animations belonged to "excellent" category, whereas 41.2% were under "needs improvement category (Table 1). Proportion of animations violating individual Multimedia learning principles were in the range of 11-17%. Minimum violation was seen with respect to Coherence principle (11%). In contrast, maximum violation was seen with Redundancy Principle (17%) (Table 2).

Table 1: Distribution Of Animations Based On Focus Index Scores

Category	Focus Index Score	Number Of Animations (n)	Percentage Of Animations
Excellent	5	61	59.8
Needs Improvement	1-4	41	41.2

Table 2: Distribution Of Animations Based On Compliance/ Violation Of Individual Multimedia Learning Principles

Multimedia Learning Principle	Percentage Of Animations Complying With Each Principle	Percentage Of Animations - Violating Each Principle
Coherence	89	11
Signalling	85	15
Redundancy	83	17
Spatial Contiguity	84	16
Temporal Contiguity	85	15

Discussion: In this study we evaluated the design of free online animations in Biochemistry based on Mayer's multimedia learning principles. Animations have been used by students to learn complex molecular concepts[2].

Students who received lecture with supplemental animations (animations with duration of 1-2 minutes each) had scores significantly higher as compared to students that were given the same lecture without animations[7].

Majority (59.8%) of animations belonged to "excellent" category with a FI score of 5. The design of these animations was consistent with all the Multimedia learning principles that reduce extraneous processing. These animations have the potential to provide best learning outcomes owing to enhance ability of learners to focus on relevant content.

Significant portion (41.2%) had a FI score between 1-4 and belonged to "Needs improvement" category. Learners who use these animations expend their significant cognitive capacity in attending to extraneous content in the animation, thereby resulting of lack of cognitive capacity for deeper understanding of knowledge content, leading to poorer learning outcomes. We used a binary approach for classifying animations as "excellent" and "needs improvement category" based on FI score, instead of multiple categories; for instance, "excellent", "good" and "needs improvement".

The rationale being- we may not be practically able discriminate between the effects on quantitative learning outcomes due to major violation of a single principle in "good" animation and minor violations of two or more principles in "needs improvement" animation, unless that is supported by interventional studies. In the absence of availability of animations with "excellent" FI score, animations can be chosen for learning activities based on ones with highest score available and detailed analysis of compliance with individual principles. 16% and 15% of the animations violated spatial and

temporal contiguity principles respectively, suggesting that lack of spatial and temporal coordinated presentation of text, verbal statements and pictures may result in poorer learning as the learner utilises the all available cognitive processing to make sense of the presented content. 17% of animations violated redundancy principle suggesting that the learners who use these animations are distracted by redundant text on the screen, when the same is being verbally stated. Since cognitive capacity of a learner is limited and most of it is utilised in processing the redundant text/words, there is not enough cognitive capacity available for learning all the intended content.

15% of the animations violated signalling principle suggesting the learners who used these animations may face challenges in focussing on the essential content because of lack of highlighting visual cues (such as arrows, flashing of relevant portion of the animation). Minimal violation (11%) was observed in Coherence principle. Learning outcomes may be poorer through these animations as the learner's cognitive capacity is spent on processing irrelevant material in the content ex. irrelevant facts, pictures, background music etc.

In summary, violation of these principles leads to learner utilising his cognitive capacity on extraneous content either attributed to irrelevant content or inappropriate layout of the lesson.

These results in the learner not being able to select, organise and integrate presented information. Consequently, the learner engages in superficial learning and fails to deeply understand the content of animation, leading to failure of achievement of instructional objectives.

Our study had several strengths. To our knowledge, this is first study to provide insights into the design aspects on online animations in Biochemistry based on Multimedia learning principles that reduce extraneous processing, and its implications for MBBS students. We used two of the most popular search engines i.e.www.google.com and www.youtube.com and hence our study would be representative of the way animations are searched online[8]. We covered animations across 27 diverse ranges of topics across Biochemistry syllabus for MBBS students, thereby ensuring the inclusion all target topics for animations[1]. Our framework for analysis of animation design was based on evidence based Multimedia learning principles.
A unique element of this study was the application of FI score for analysing the design quality of animations. FI score can be used to evaluate the learning potential of animations based on management of extraneous processing.

Our study had few limitations. Multimedia learning 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[3]. We welcome future studies that could test the effect of these variables on learning through animations.

Conclusion: While it is automatically assumed that any multimedia presentation ex. an online animation may potentially lead to intended learning outcomes, this may not be the always the case as we demonstrate in this study. There is a paucity of studies that have evaluated the effectiveness on online animations in Biochemistry.

We analysed these animations using framework based approach dependent on multimedia learning principles for reducing extraneous processing. We found that significant proportion of online animations in Biochemistry had limitations in design, as they violated Multimedia learning principles.

MBBS students who use such animations may suffer poor learning outcomes attributable to poor design elements. Medical publishing companies and individuals who create animations could incorporate all the Multimedia learning principles that reduce extraneous processing during the design of animations in Biochemistry for effective learning.

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