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Original article

Do Online Genetics Animations Promote Deeper Learning? An Analysis Based on Multimedia Learning Principles

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Abstract

Introduction: Learning complex concepts in genetics is important for MBBS students for understanding the rationale behind the pathophysiology and management of many diseases. MBBS students have been shown to access online animations to learn complex concepts. However, there is lack of evidence regarding the quality of online animations in genetics. The objective in this study was to evaluate the design quality of online genetics animations to assess their potential to promote deep learning.

Methods: Our study sample consisted of 59 online animations belonging to 17 topics shortlisted from Genetics. Genetics is an integral part of Ist year MBBS Biochemistry syllabus. These animations were shortlisted after performing an online search on www.google.com and www.youtube.com. These animations were evaluated using 6 multimedia learning principles that facilitate deeper learning. Animations were scored based on their compliance/violation of Multimedia learning principles

Observations and results: The shortlisted genetics animations had a median score of 4 (interquartile range=0). None of the animations had a maximum score of 6. Personalisation and pretraining principle was violated in 95% and 93% of animations, respectively.

Conclusions: Online genetics animations that we analysed in this study are not consistent with all the 6 multimedia learning principles and hence may not facilitate deeper learning of concepts among students. Teachers and students should be aware of pitfalls of using such animations. To enhance their potential as effective learning aids, animations may be created incorporating multimedia learning principles that promote deeper learning.

Key words: Online animations, MBBS students. multimedia learning principles

Introduction

Genetics forms an important component of Biochemistry syllabus for MBBS Ist year students.[1] Leaning complex molecular concepts in genetics is an important prerequisite for understanding scientific basis underlying etiology, pathophysiology and management of many diseases. Furthermore, students needs to famialiarise themselves of genetic underpinnings of health and disease to critically evaluate huge amounts of evidence generated through research.

Animations designed in a way consistent with multimedia learning principles have been shown to promote deeper learning.[2] MBBS students have been shown to access online animation videos to learn complex concepts.[3] However, concerns have been raised regarding the educational quality of online videos.[4-9] Moreover, there are hardly any studies that have evaluated the design of online genetics animations based on multimedia learning principles to assess their potential for deeper learning.

Aims and Objectives

Our objective in this study was to evaluate the design quality of online genetics animations to assess their potential to promote deeper learning.

Materials and Methods

In this cross-sectional study, we evaluated online animations related to genetics topics. Ethical approval was not required for this study as human subjects were not involved in this study and all the data (animations) used in this study can be accessed by public. Our study sample included 59 online animations in Genetics.

MBBS Ist year Biochemistry syllabus prescribed by National Medical Commission (NMC) of India in the year 2019 was reviewed and 17 Genetics topics were shortlisted .[1] Animations related to shortlisted topics were searched on two most popular search engines www.google.com and www.youtube.com using relevant key words.[10] The popularity of these search engines as a source of animations was corroborated by an informal survey of MBBS Ist year students in our institute. The search was performed with default settings without using any advanced search options. This approach was deliberately chosen to simulate routine search strategies of students. Date of access of animations was July 24th and 25th, 2021. In the context of this study, an animation was defined as follows- "Animation refers to a simulated motion picture depicting movement of drawn or simulated objects".[2] 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.
3. Animation should be in english language.

Exclusion criteria-

1. Animations that require payment or that require user credentials for access.

A total of 59 animations were shortlisted using the above inclusion and exclusion criteria.

We used multimedia learning principles to analyse the design quality of online animations in Biochemistry to assess the potential of these animations to foster deeper learning.

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:** Learning is better when extraneous words, pictures and sounds are excluded in the multimedia presentation rather than included..
2. **Signaling Principle:** Learning is better when essential words/graphics are highlighted through cues in a multimedia presentation.
3. **Redundancy Principle:** Learning is better when graphics and narration are used in multimedia presentation rather than graphics, narration and on-screen text.
4. **Spatial Contiguity Principle:** Learning is 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:** Learning is better 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**: Learning is better when words used in the multimedia presentation should be in conversational style rather than formal style.
9. **Image Principle**: It states that there no evidence to show that speakers image on the screen would improve learning outcomes.
10. **Multimedia principle:** 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 is 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.
Animations designed incorporating the above principles reduce extraneous processing, manage essential processing and enhance generative processing, thus contributing to improved learning outcomes.[11,12]

Extraneous Processing, Essential processing and Generative Processing:

a. **Extraneous processing:** Extraneous processing is type of cognitive processing that that does support instructional goal. It is attributed to presence of extraneous material (irrelevant images, spoken words) in the animation. Extraneous content in the animation diverts cognitive capacity towards attending to extraneous material and the learner is left with insufficient cognitive capacity to learn presented 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 that involves selecting essential content (images and words) in the animation and representing them in working memory. It precedes deeper understanding of the presented content. It is attributed to complexity of material in animations. Complex animations divert all available 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 may be incorporated in the animations to manage essential processing.

c. **Generative Processing:** Generative processing is a type of cognitive processing necessary for deeper learning 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 due 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.[12]

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. Specifically, the principles that manage essential processing and foster generative processing play a very important role in deep learning of concepts in multimedia

presentations like animations.[11,12] Hence we chose six principles ie Segmenting, Modality, Pretraining, Personalisation, Image and Multimedia principles in our study.

Scoring of Animations: The shortlisted animations (n=59) were evaluated using 6 of the Mayer's multimedia Learning Principles. Voice principle was not used as discussed before. Since the users can pause/play animations as per their convenience and complexity of animation, it was assumed with segmenting principle was naturally complied with in all the animations. 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 6. Total score for an animation was obtained after adding all the scores for individual principles. Hence, an animation with higher score indicates higher the degree of compliance with these six multimedia learning principles, and learner is expected to show better learning outcomes in the form of deeper learning, as compared to the ones with lower scores.

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

Observations and Results

A total 59 animations had a median score of 4 (InterQuartile Range =0) out of a maximum score of 6. Pretraining and Personalisation principle was violated in 52 (88%) of the animations.

Table 1. Distribution of animations based on scoring using 6 multimedia learning principles

Number of animations (%)	Scoring on animations using multimedia Principles (Maximum score=6)
0	1
0	2
5 (8)	3
47 (80)	4
7 (12)	5
0	6

None of the animations complied with all the 6 multimedia learning principles. Only 7 (12%) had score of 5 (maximum score =6). Majority of animations (80%) had a score of 4 indicating that such animations may have violated any of the two principles(Table 1).

Table 2.Distribution of animations based on compliance/violation of individual Multimedia principles

Sl no	Name of the Principle	Number of animations complying with each principle (%)	Number of animations violating each principle (%)
1	Pretraining	4(7)	55(93)
2	Modality	54(92)	5(8)
3	Segmenting	59(100)	0
4	Personalisation	3(5)	56(95)
5	Image	59(100)	0
6	Multimedia	59(100)	0

Personalisation principle was violated in 95% of animations, as the spoken words in these of the animations were in formal style rather than conversational style. Pretraining principle was violated in 93% of the animations, indicating that there was a lack of introductory session with names and features of components/steps prior to start of animation in these animations. Image, multimedia and segmenting principles were complied with in all the animations(Table 2).

Discussion

In this study we evaluated the potential of online genetics animations to facilitate deeper learning . It is well established that animations that are consistent with multimedia learning principles promote deeper learning of concepts .[2,11] We evaluated online animations using 6 multimedia learning principles that manage essential processing and enhance generative processing based on cognitive theory of multimedia learning.[11]

Personalisation principle was violated in majority (95%) of the animations. These animations use formal style of narration rather than conversational style. Consequently, there is failure to elicit a social response in the learner leading to lack of motivation. As a result the learner does not attempt to put extra effort to mentally organize and integrate presented knowledge (images and spoken words) in the animation. Consequently, due to impairment in organization and integration, the learner is unable to mentally construct " image-word"model that is required for deeper learning. Similarly, 93% of the animations did not comply with pretraining principle indicating that there was lack of introductory session containing brief information about the names and charactersitics of components/steps, prior to the animation. As a consequence, the learner may be potentially overwhelmed by the complexity of presented information. This results in the learner not being able to select essential content in the animation to form mental representations of relevant images and sounds. This is a precursor to deeper learning. Majority (88%) of the animations violated both personalization and pretraining principle. Users of such animations may have potential problems due to challenges in selection, organization and integration of presented content leading to failure of deeper learning.[11,13]

None of the animation had an "ideal" score of 6. Minority (12%) had a score of 5 indicating a violation of 1 principle. Majority(80%) of the animation had a score of 4 , suggesting a violation of any of the 2 principles. 8% of the animation violated three principles. An animation that violates multiple principles could potentially result in cumulative adverse effects on learning outcomes. These effects

may be determined by two factors-1. The number of principles violated in the animation 2. The type of principles violated in the animation ex. whether all the violated principles manage selection of essential content or whether they impact the whole pathway of learning- mental selection, organization and integration of presented material. Effects of such violations can be precisely determined through robustly designed interventional studies.

Our study had certain strengths. To our knowledge, there this is the first study that has evaluated online genetics animations using multimedia learning principles. These principles are evidence based and have been used to design animations to promote deeper learning. The topics were chosen from MBBS Ist year Biochemistry syllabus thereby making it relevant to medical students. We used the most common search engines www.google.com and www.youtube.com and hence our findings are representative of student's search patterns and accessed animations to some extent.[10]

Our study had few limitations. Generally , these principles (findings) are more strongly applicable when the topic is complex, learners have low prior knowledge of the topic and pacing of animation is fast.[11] Given the size of vast pool of online genetics animations on www.google.com and www. youtube.com, additional studies may be done to confirm our findings. In addition, our search strategy deliberately involved default settings without the use of advanced search options to simulate day-to-day search activities of learners. In doing so, it is possible that we may have missed high quality of animations. Future studies that account for these variables in their methodology may be undertaken.

Creating animations is a resource intensive process. [14] As opposed to creating new animations , in view of majority of animations violating multimedia learning principles, we recommend that teachers could use these easy to implement compensatory measures in a classroom setting, -If personalization principle is violated in an animation, teachers could replace the default formal style narration with one in conversational style ; an introductory session familiarizing the names and characteristics of components/steps before showing the animation to students can be conducted to compensate for violation of pretraining principle.

Conclusions:

Majority of online genetics animations that we evaluated donot follow atleast two of six multimedia learning principles and hence may not foster deeper learning. In view of the huge pool of such online genetics animations just a click away, teachers and students should be aware of pitfalls of using such animaitions. Teachers could use the approach in this study to rate animations and recommend the best to their students for learning. It is also an opportunity for government and corporate organisations to fund initiatives to develop freely accessible online genetics animations whose designs are consistent with multimedia learning principles to address the lack of quality online educational resources.

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