

The Effectiveness of Representations of Abstract Bio-chemical Processes in Education

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Abstract

Visual communication of abstract scientific concepts is a widely used technique in education. Its effectiveness is viewed differently by various target groups, and it is important to aim the correct visual representation at the desired target group for it to be most effective. We present the results of a study that contained five different representations and had two iterations. Our versions of representing the ATP synthesis process include 2D Detailed and 2D Abstract representation, Narrated Video, Video without Narration, and Hybrid Representation. These five versions were evaluated by 60 students who were randomly assigned one of the versions and nine experts who viewed and compared all five of the representations. In our iterative study, we aimed to find out what form of representations students and experts prefer; overview or continuous representations, simple or detailed representations, and whether they prefer static images or videos for representations of biochemical processes in education. The quantitative results showed that students find 2D Detailed Illustration the most useful for learning and overall find the animations (Narrated, without Narration, and Hybrid) to be more confusing than static images. In contradiction, the experts have expressed favour for the Narrated Video, followed by the Hybrid representation, while least favouring the 2D static images.

1. Introduction

Bio-medical visualisation and medical art are extensively used in education. The need to present a suitable representation of different occurrences is important as it yields higher success in learning outcomes. However, the requirements and preferences for such representations differ between experts in the field and students who are trying to grasp the context. Biochemical processes are invisible to the naked eye and need to be represented accurately due to their abstraction. Previous research has shown the benefits of both static images and animated videos in explaining concepts in biomedical fields [PS18,GDVZ21]. Medical visualisation also utilises the Theory of Multimedia Learning to create content that is effective for learning based on not over-stimulating the sensory load.

In our study, we aimed to take the benefits of the static 2D representations and combine them with animated representations to create a Hybrid overview representation of the whole process of ATP synthesis and compare it to 2D Abstract and 2D Detailed illustrations, Narrated Video, and Video Without Narration (see Figure 1) to evaluate these modes of process illustration. We carried out a series of studies to investigate what kind of representations are suitable for which target group (i.e., students/general public and experts) and why. Because target groups with different levels of knowledge need different representations, we decided to focus

on the following research questions; our main focus was finding out whether abstract biochemical processes are more beneficial to view in one continuous manner or in segmented parts, creating an overview. We also focused on finding out whether there is a difference between the groups in preference for static or moving representations as well as preference for abstract representations or detailed ones. Because of the different benefits of the simplicity and overview that static images offer and the spatial and movement information that animations offer, we hypothesised that a hybrid representation consisting of sequence of short videos would be the most useful in education.

2. Methods

Our study consisted of two rounds of surveys based on online questionnaires. In the first round, an international population of students (n=60) with biochemistry, IT, and other backgrounds were asked to participate. For each of the students, we randomly generated one of the five representations; 2D Static Abstract, 2D Static Detailed, Narrated Video, Video Without Narration, and a Hybrid Representation. They then answered content questions that also tested the understanding of the order of the events in the process. They were then asked to answer open-ended questions about their impressions of the representation. The second round of surveys focused on experts in the field of biochemistry and visualisation (n=9), who were also asked to answer questions through an online questionnaire. They were asked to view all five of the representations and answer

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