Teachers' Contribution to the Enactment of Animations in Class while Studying Biotechnological Methods

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Abstract

Animations have a great potential for improving the way people learn. A number of studies related to different scientific disciplines have shown that instruction involving computer animations can facilitate the understanding of processes at the molecular level. However, using animations alone does not ensure learning. Students sometimes miss essential features when they watch animations alone, mainly due to the cognitive load involved. In addition, students seem to attribute a great deal of authority to the computer and may develop misconceptions by taking animations of abstract concepts too literally. In this study we attempted to explore the contribution of the teacher to the enactment of animations in class. Two exemplary biotechnology teachers participated in two case studies, aimed to characterize teachers' contribution to the enactment of animations in class while studying biotechnological methods. Our findings reveal that teachers' contribution is pronounced in the following three aspects: establishing the "hands on" point of view, helping students deal with the cognitive load that accompany the use of animations and implementing constructivist aspects of knowledge construction while studying using animations. We have also recognized two alternative approaches of teachers in terms of supporting students' knowledge construction while studying from animations.

Key words: Animations, Biotechnology education, Cognitive load, Constructivist teaching, Teaching in computerized environments.

Introduction

Animations have a great potential for improving the way people learn (Mayer and Moreno 2002; Hoffler and Leutner 2007). A number of studies related to different scientific disciplines have shown that instruction involving computer animations can facilitate the understanding of processes at the molecular level (Williamson and Abraham 1995; Sanger, Brecheisen and Hynek 2001; Stith 2004; Yarden and Yarden 2009). However, using animations alone does not ensure learning. It is occasionally linked with simplified models of the scientific process, that can give students the impression that every variable is easily controlled (Hennessy, Deaney and Ruthven 2006). According to Kelly & Jones (2007), students sometimes miss essential features when they watch animations alone, due to the cognitive load involved (Hegarty 2004). In addition, students seem to attribute a great deal of authority to the computer and may develop misconceptions by taking animations of abstract concepts too literally (Wellington 2004). In order for students to learn new concepts and processes they encounter in animations in a meaningful way, according to constructivism (Ausubel 1963) they should relate the new knowledge and information they come across with concepts and claims they already hold. For that purpose, we believe that the way in which a teacher enacts the animation in class plays a crucial role. In this study we attempted to study the contribution of the teacher to the enactment of animations in class, while studying biotechnological methods.

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Methodology

Context

In this study we used two animations we previously developed for the use of high school biotechnology majors. Those animations are aimed to introduce the following biotechnological methods: gene cloning and the construction and use of genomic DNA library (http://stwww.weizmann.ac.il/g-bio/geneengine/animations.html). The animations include interactive features and accompanied by computerized tasks.

Sample

Two exemplary biotechnology teachers participated in two case studies, aimed to explore teachers' contribution to the enactment of animations in class while studying biotechnological methods. Two biotechnology major classes (culturally non-deprived population, each class about 25 students) were chosen according to their teachers' initiative and motivation to take part in this study, as well as due to their extensive teaching experience (more than ten years). Both teachers, Ravit and Dora (pseudo names), possess previous formal knowledge in molecular biology and laboratory research.

Procedure

During the lessons being documented, in Ravit's class the animations were viewed simultaneously by all of the students, through the guidance of Ravit. In Dora's class however, in one lesson the students worked in pairs, while in the other lesson the animations were viewed simultaneously by all of the students, through the guidance of Dora. In both cases, the lessons were based on the animations being used, and both teachers employed specific strategies developed before-hand for using the animations.

Data analysis

The enactments of the animations, in two exemplary biotechnology majors' classes, were audio - taped and fully transcribed. The transcripts were qualitatively analyzed according to the narrative constructivist procedure recommended for multiple-case analysis (Shkedi 2005). Following mapped and focused categorizations, the two teachers were interviewed. In the interviews the teachers were asked to explain representative episodes of the class observations transcripts, illustrating the main categories resulting from the focused categorization. Teachers' interviews were audio - taped and fully transcribed.

Results

The analysis revealed that biotechnology teachers' contribution to the enactment of animations is pronounced in the following three aspects: establishing the "hands on" point of view, helping students deal with the cognitive load that accompany the use of animations and implementing constructivist aspects of knowledge construction while studying using animations.

Establishing the "Hands on" Point of View

Both Ravit and Dora emphasized how the biotechnological methods, which were introduced in the animations, are carried out in practice in the lab. In her interview, Ravit explained why it is important to discuss with the students the rationale behind different stages of a biotechnological method, being demonstrated in the animation. She believes the students should understand what is the rationale behind each step they see in the animation, and how it is really done in the lab: "In the animation that demonstrates the creation of a DNA library the stage of blotting is being demonstrated, but the rationale, why it has to be done like that, using a filter, can not be fully described. We want to demonstrate the biotechnological methods dynamically to the students, and we also must explain to them, for example, why we are not adding the detector to the gel, or why it is important to add the detector to the filter".

Another way of establishing the "hands on" point of view was by discussing with the students and bringing up to their awareness the existence of some steps that were skipped from the animation, still important while performing the relevant biotechnological method in the lab. In the next example from classroom observation, Dora is discussing with her students the of a step that is not present in the cloning animation they watch:

Dora rationale: Tell me, what we should do to the bacteria in the lab in order to get an effective transformation?
Student1: We should heat them
Student2: We should heat them more and more
Dora: And in that way we'll create more temporal holes in the cell wall as well as in the membrane, which enables us the transformation with plasmids.

Afterward in her interview, Dora is stating that without the discussion on the steps of the biotechnological method and their rationale, the students might learn incompletely the biotechnological methods as they are being demonstrated in the animations: "Those steps are missing in the animation but it is not terrible at all because we discuss them together. Even if the animations had included all steps, still the students might not think why there is a need to perform each step".

Helping the Students Deal with the Cognitive Load

Both Ravit and Dora tend to guide their students while watching the animations. They focused their students' attention on important details in the animation, and kept asking the students different questions about objects in the animation. In the next example, Ravit is making sure that her students understand the function of each site in the plasmid, which is being introduced in the cloning animation:

Ravit: Now look, we have two test tubes. In test tube A you can see there is a plasmid…
Student: It has an antibiotics resistance site
Ravit: What site is it?
Student: The one that is named tetracycline
Ravit: Right. What are the other sites?
Student; There is a restriction site
Ravit: Right, What more?
Student: An origin replication site.

In her interview, Ravit explained that by guiding students through watching animations she is making the animation more comprehensible for her students: "look, I could seat, read a book, and let them watch the animation alone till it ends. I believe that in that way they will lose some important points because they have not noticed them through all the details and changes in the animation".

The importance of identifying exactly what is shown in the animation seems to direct Dora as well. In her interview, Dora summarized the kind of support she believes is essential while watching: "Focus is the key word in order to cope with the load while watching animations. For example, the students could have looked over and over again on the different kinds of bacteria in the animation, but they really need my help to focus on each of the plasmids inside the bacteria, and on its unique elements."

Besides the dynamic changes and the intrinsic cognitive load, Ravit explains that she is directing the students while they watch the animations because of *the nature of the subject matter* (the biotechnological methods), that is abstract and complex. According to Ravit, especially in animations of this topic, carefulness is needed during watching in order to identify, for instance, fundamental differences between the structures of similar molecules: "I'll tell you, in the case of the structure of carbons, in a first look everything looks the same. The student may notice the difference, or not. This small difference between molecules can make a huge difference in understanding".

Implementing Constructivist Aspects of Knowledge Construction

Both Ravit and Dora implemented elements of constructivist teaching while they used animations in class. They both considered the activity with the animation as important in the construction of students' knowledge and understanding of the biotechnological methods. For that purpose, one of the things that were done by Ravit was to establish clearly the activity with the animation on students' prior knowledge:

Ravit: Let's see in the animation how to create a recombinant plasmid, but before that, can someone please tell us how it is done? How we link a gene, a fragment of DNA into a plasmid?

Another thing both Ravit and Dora did, in order to make the activity with the animations more meaningful, was to connect it explicitly to other activities on the students' learning sequence, such as lab experiences:

Dora: Nofar [a student] is asking an interesting question regarding the animation: 'How can we tell who the insert in the end of the cloning is?' Since we cloned here two plasmids, we really can not tell which the insert is and which the recombinant plasmid is.
Student: But when we deal with a DNA and a plasmid…
Dora: Right. In your next projects in the lab you will take a fragment of DNA from a virus and clone it in a plasmid. In that case the insert is the fragment from the virus and the plasmid has received it.

In her the interview, Ravit is stressing why she believes it is so important to link the activity with the animation to the other learning activities the students are exposed to: "It is most important to link the activity with the animation to the tour, to experiences we had in the lab. Otherwise the student might say: 'this belongs to the lab, this to the animation, there is no connection between them'. That is why all the time, while I work with the animation, I keep going back to what I have already taught in other occasions. The student is curious, if he does not understand something from the animation he can go back to other learning experiences he had."

While the constructivist aspects being introduced so far were common to both Ravit and Dora, the next aspect of using animations in a constructivist way was reflected differently in the two case studies. This aspect was identified as supporting students' understanding of biotechnological methods while studying using animations. In her interview, Ravit explained why, for instance, the conceptualization of processes the students had just watched in the animation is so important: "The students are watching a process in the animation but they must know the name of it, the concept behind what is being demonstrated in the animation. For example, you can not study the process of taking a gene and inserting it into bacteria without the concept transformation, and without the concept that the bacteria who received the gene is a transformant".

While Ravit bases her supporting efforts while enacting the animations on her own pedagogical knowledge, Dora is basing her supporting efforts on students' difficulties and misunderstandings she is exposed to during the enactment of the animations. In her interview, Dora reveals that after examining the animation with her students she became aware to the places where the students needed assistant in order to gain meaningful understanding. Her presence in those points enables her to support the students through studying the animation, whenever they encounter concepts or objects which were not so comprehensible: "When I was exposed to students' specific difficulties through their watch of the animation I had the opportunity to put a spot light on objects and concepts in the animation which are not understandable enough to the students".

Discussion

Learning from animations is not a simple task, even though it might seem like. Although animations can provide learners with explicit dynamic information, the inclusion of a temporal change introduces additional information-processing demands (Lewalter 2003). In this study we have identified teachers' essential support in universal aspects, such as helping students comprehend while studying from animations, despite the cognitive load involved, as well as in particular aspects for studying biotechnological methods from animations, as establishing the "hands on" point of view. We have also recognized two alternative approaches of teachers in terms of supporting students' knowledge construction while studying from animations. The teacher’s role seems critical in terms of promoting students' thinking while studying from animations about underlying concepts and relationships being introduced. We suggest that students and teachers work together in transforming knowledge while studying from animations, as in other lessons and activities in school (Scardamalia and Bereiter 1991).

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