Supporting learning biotechnological methods using interactive and task included animations

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The conditions and the components of animations, under which they are most effective in promoting comprehension of biotechnological methods, are characterized in the course of this study. Here we describe the use of an animation we developed in order to visualize the main steps of the Polymerase Chain Reaction (PCR) method. The animation was developed in two alternative versions: a continuous version, and a sequential and interactive version (“step by step”). The animation is accompanied by three computerized tasks, aimed to identify students' attention to key issues in the PCR method, and to the symbols which appear in the animation. One hundred and twenty three 12th grade biology majors were divided into three groups and were exposed to three different treatments: cards with still images, animation and task included animation. The results indicate that all the three visualizations tools were useful for learning the PCR method, despite a significant difference which was identified between the groups in terms of the prior content knowledge. From observing students' work with the animations we learnt that even though the students were not told to view the animation in any specific order, most of them watched first the interactive version ("step by step").

Theoretical background

Animations were previously shown to promote understanding and improve learning (Sanger, Brecheisen and Hynek 2001; Mayer and Moreno 2002; Stith 2004; Stromme and Jorde 2005). Recently, the possible contribution of instructional aids or tasks, which are integrated into the animations, was investigated (Kramer, Prechtl and Bayrhuber 2004; Lowe 2004). Those instructional aids were developed to support simultaneous learning of text and pictures, as commonly appear in animations, since simultaneous appearance of text and pictures tends to impose a cognitive load on learners (Mayer and Moreno 2002). Another difficulty that is taken into consideration is whether students' comprehension processes can keep up with the rapidly changing stimuli shown in dynamic displays. It seems that better support for learning occurs when learners can speed up or slow down the display to match their personal rate of comprehension (Hegarty 2004).

Key objectives and Research questions

We attempt to characterize the conditions and the components of animations, under which they are most effective in promoting comprehension of biotechnological methods, that are part of adapted primary literature unit in biotechnology, used for learning advanced biology in high schools in Israel

(Yarden, Brill and Falk 2001), as well as in an obligatory unit in genetic engineering for biotechnology majors (Israeli Ministry of Education 2005). Since most students usually have no opportunity to experience hands-on biotechnological methods, we attempt to use animations as visualization tools in order to support learning.

Here we focus on the following research questions:

1. What are high-school biology students' experiences, preferences and attitudes towards working in computerized learning environments?
2. Is there a correlation between students' prior content knowledge and their understanding of the method being learned using the interventions?
3. Which visualization tool (cards, animation or task included animation) is more effective in promoting learning of the biotechnological method?
4. What are students' preferences with regards to the interactivity of the animation?

Methods

The animation

Here we describe the use of an animation we developed in order to visualize the main steps of the Polymerase Chain Reaction (PCR) method. The animation was developed in two alternative versions: a continuous version, which shows the whole procedure continuously, and a sequential version, which shows the procedure gradually, or "step by step". Those two versions are accompanied by three computerized tasks. The tasks are aimed to identify students' attention to key issues in the PCR method, as well as to the understanding of the symbols and images which appear in the animation.

The sample and the research tools

One hundred and twenty three 12th grade high-school biology majors participated in this phase of the study. All the students were from seven parallel classes; they were divided into three groups and were exposed to three different visualization tools. At the beginning of the lesson the students in all three groups were asked to answer a written questionnaire. In this questionnaire the students were asked to respond to true/false sentences and to answer open questions which were designed to examine their prior content knowledge in topics which are relevant for understanding the PCR technique (e.g. DNA replication). Subsequently, a 4 point Likert-type scale (4 = strongly agree and 1 = strongly disagree) was used to probe students' experiences and attitudes towards learning using computerized learning environments. Once filling the first questionnaires, the students in one group (N=33) received cards with still images taken directly from the animation and were asked to read the text and watch the still images in order to learn about the PCR method. The students in the second group (N=38) watched the PCR animation, using the continuous and the "step by step" versions. The students in the third group (N=52) watched also the two versions of the PCR animation, only this time the animations were accompanied with the computerized tasks. Subsequently, the students in all three interventions answered a second questionnaire which examined their understanding of the PCR method. The students who used the animation (second & third groups, N=90) also answered a Likert-type scale feedback questionnaire about the animation. It should be emphasized that all the students learned about the PCR method for the first time through these activities and their teacher did not discuss this method in advance. During learning with the various alternative visualization tools the students worked in couples. The work of 12 selected couples (24 students) who worked with the animation was audio-taped, and then transcripts were prepared and qualitatively analyzed.

Results

Students' experiences and attitudes towards working in computerized learning environments

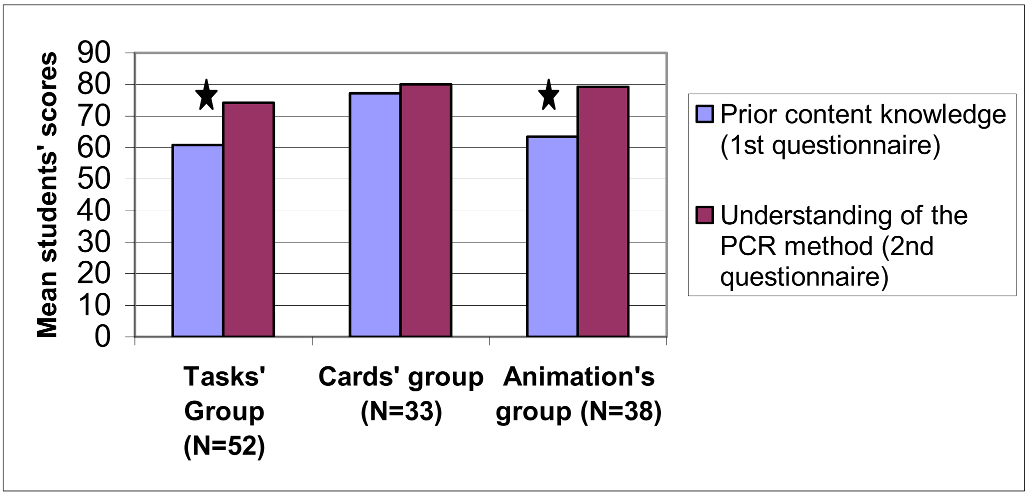
Students' previous exposures and experiences with common computer programs in general, and with animations in particular, were initially examined. Their preferences while learning using computerized learning environments, as opposed to learning from a teacher or textbooks, were also examined. Analysis of the relevant section in the first questionnaires revealed that all of the students in our sample have computers with an access to the Internet at home. Most of the students reported they are familiar with common computer programs, i.e. Word, Excel and Power Point. On the other hand, about 50% of them have no or relatively minor experience with animations. Still, when the students were asked to state their preference for informative presentations, versus computerized tasks or animations, most of them reported to prefer computerized tasks and animations as the most effective learning tools.

Most of students reported they prefer learning with the teacher than learning by themselves or by computerized learning environments. When they do not have the opportunity to learn with their teacher, the students reported they prefer learning using computerized learning environment than learning alone using textbooks. Moreover, the students stated that they prefer learning new processes using computer visualizations rather than visualizations that appear in textbooks. The students also stated they prefer learning in couples than alone.

Students' performances in the questionnaires

Analysis of the first and second questionnaires revealed a significant difference ($p<0.05$) between the groups in terms of the prior content knowledge (see Figure 1). The mean scores of the Animation and the Task groups' prior content knowledge were significantly lower in comparison to the Card group .However, in the second questionnaire, which checked students' understanding of the PCR method, no significant differences were found between the mean scores of the three groups.

Figure 1: A comparison between mean students' scores, prior and following treatment with various visualization tools.



Students' preferences with regards to central features of the animations

From analyzing students' conversations (N=12) while learning the PCR method using the animation as well as analyzing the feedback questionnaires (N=90), we learnt that the students in both groups (the Animation's and the Tasks' groups) found the "step by step" version of the animation more effective than the continuous version, when using it at the initial stages of learning the PCR method. However, the students stated that the continuous version can serve as a summary tool, following learning the PCR technique. The students also stated that the text and the accompanied computerized tasks are important and helpful.

Discussion

Here we focused on comparing learning the PCR method using three alternative visualization tools: cards with still images, animation and task included animation. We also learnt about the use of interactive animation (the "step by step" version), versus the non-interactive animation (the continuous version). We found that all three visualizations tools were useful for learning about the PCR method. However, we found that students from the Animation's and the Tasks' groups, who their prior knowledge was significantly lower than that of students' from the cards' group ,were able to use the animation, learn from it and close the gap in their knowledge. From observing students' work with the animations and analyzing the transcripts we learnt that even though the students were not told to view the animation in any specific order, most of them watched first the "step by step" version in order to learn effectively the PCR method. We believe that by studying the effectiveness of the animation's interactivity in a comparative research design, as well as studying the impact of different kinds of tasks included in the animation on students' comprehension, we might be able to determine distinct terms under which the use of animations is most valuable in promoting learning.

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