Teaching Science via Animated Movies: Its Effect on Students' Learning Outcomes and Motivation

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Abstract

Some researchers claim that animations may evoke misconceptions or hinder students' meaningful learning. Our research was conducted in order to examine these assertions and investigate the effect of teaching via BrainPop animated movies on students' learning outcomes and motivation to learn. Applying the quantitative methodology, two pre- post-questionnaires were administered: *Science thinking skills* and *Motivation to learn science*. Students' overall achievement in science was examined by their grades in the report-cards. The research population (N=1335) was divided into experimental (N=926) and control (N=409) groups from 17 elementary schools. Finding indicated that the use of animated movies enhanced students thinking skills, in terms of: science understanding, knowledge implementation, and reasoning ability. Our study also indicated that students who studied science with the use of animated movies developed higher motivation to learn science, in terms of: self-efficacy, interest and enjoyment**,** connection to daily leaving, and importance to the student's future, compared to students who studied science in a traditional way. The animated movies had both visual-pictorial and auditory-verbal capabilities. This and the fact that students were engaged in active learning can explain the positive and high correlation between thinking skills and motivation to learn science among the experimental students.

Keywords: animated movies, science learning, motivation, thinking skills.

Introduction

The development of Java, Flash, and other web-based applications allow teachers and educators, nowadays, to present complex animations (Flemming, Hart, & Savage, 2000). Some studies that investigated the use of animations in the classroom found that the learning process improved (Najjar, 1998; Rieber, 2002; Williamson & Abraham, 1995). However, some researchers claim that since animations are in most cases a simplified version of a phenomenon, they might evoke misconceptions (Mayer, Heiser & Lonn, 2001) and may hinder meaningful learning by preventing students from using their imagination in creating their own mental models (Schnotz & Rasch, 2005).

In science education, computerized modeling and animations are used for describing, explaining, and predicting scientific processes. Abstract scientific phenomena occurring in the macroscopic level (such as the movement of planets) or in the microscopic level (such as molecules and atoms) can be attractively illustrated by animated movies. Animations are employed for enhancing the transitions from abstract to concrete mental operations and vice versa (Barak & Dori, 2005; Barak & Rafaeli, 2004; Dori & Belcher, 2005). The use of animated movies was found to have a positive affect on students' learning motivation and thinking skills (Rosen, 2009). Thinking skills and cognitive operations are associated with Bloom and

colleagues (1956). According to their taxonomy, 'knowledge' and 'understanding' are examples of lower order cognitive operations, or thinking skills, whereas analysis, synthesis, and evaluation are considered as higher order thinking skills. Among the various higher order thinking skills, reasoning ability is essential for the development of learners' critical thinking and argumentation skills (Barak & Dori, 2009). In our study, we examined students' lower order thinking skills – understanding of scientific concepts, and higher order thinking skills - their reasoning ability, as they studied science with the use of animated movies.

Research Goal and Population

Our research was based on an innovative program in Israel that integrated web-based animated movies into the science curriculum of 4th and 5th grade students. Our goal was to examine the effect of teaching via animated movies on students' learning outcomes with emphasis on achievements and motivation to learn science.

Our research questions were: Does, and to what extent learning via BrainPop animated movies affect students':

A. Thinking skills, in terms of: understanding, implementation, and reasoning*?
B. Motivation to learn science, in terms of: self-efficacy, interest and enjoyment, connection to daily leaving, and importance to the student's future?
C. Grades in science in their report cards?

Research Methodology and Tools

The research was based on the quantitative methodology using the pre- post- experimental design (Campbell & Stanley 1963; Kerlinger, 1973). The teaching/learning method (the integration of animations) was the independent variable, while the dependant variables were: students' thinking skills: understanding, implementation (lower order thinking skills) and reasoning (higher order thinking skills); students' motivation to learn science; and, students' overall achievement in science. Our study included two questionnaires: a. *Science thinking skills* and *b*. *Motivation to learn science.*

Both questionnaires were validated by four experts in science education and three elementary school teachers, reaching 100% consent. The reliability, determined by internal consistency, Alpha Cronbach was 0.88 for the *Motivation questionnaire*. Kuder Richardson KR-20 for determining the reliability of dichotomy scales indicated 0.72 for the *Science thinking skills* questionnaires. Students' overall achievement in science was examined by the grades in their report-cards at the end of the academic years 2008 and 2009.

Research Settings

The research included three stages: A. a pilot study that was conducted in order to establish the research tools' reliability and validity, B. the main study, and C. data analysis and writing the final report. The main study included seventeen elementary schools in one municipality – Holon, located in the central part of Israel. The schools were divided into experimental and control groups according to the head principle and science teachers' preferences. The experimental schools integrated web-based animations created by BrainPop (http://www.brainpop.com) into their science education curriculum. The control schools continued teaching science courses in the traditional way – using books and worksheets with static 2D pictures. Teachers from both research groups were experienced in teaching science.

BrainPop website provides three to five minutes animated movies that explain hundreds of scientific concepts in an entertaining way. Each movie includes animated characters who lead users through educational activities, including an interactive quiz, an experiment, and a printable activity page. The animated movies provide curriculum-based content that is aligned with the Israeli national science education standards. The teachers' section contains lesson plans and ideas for using BrainPop in the classroom.

At the beginning of the study, the experimental teachers received a two-hour workshop, focusing on pedagogical principles and teaching strategies for integrating the web-based animations. In addition, the experimental teachers received guidance throughout the year by BrainPop experts. The animated movies were presented to the students at least once a week, about one animation for each topic taught in class. The teachers demonstrated the animated movies to their students in the classroom and encouraged students to work on their own or in pairs in computer clusters. The animated movies were used to provoke class discussions or to summarize a topic.

As part of our study, both the *science thinking skills* and the *motivation to learn science* questionnaires were administered before and after learning with BrainPop animations – at the beginning and the end of the school year 2008-2009.

Research Population

The research population included 1335 students. The experimental group included 926 students from five elementary schools (4^{th} graders: N=435 and 5^{th} graders: N=491). The control group included 409 students from two elementary schools (4^{th} graders: N=206 and 5^{th} graders: N= 203). Gender distribution was close to even (50.3% girls), 11.3% declared that their parents' occupation involves a scientific field (medical doctors, scientists, engineers etc.), and 12.8% declared that they participated in extracurricular activities in science education. Pearson Chi-Square test indicated no statistically significant differences between the research groups in respect to gender distribution, class, parents' occupation, and extracurricular activities distribution.

Results

The following section includes three parts. Each part provides an answer to one of the research questions.

The Effect of Animated Movies on Students' Thinking Skills: Understanding, Implementation, and Reasoning

Analysis of the pre- and post questionnaires indicated a statistically significant difference between experimental and control group students ($F=127.50$, $p<0.001$). We found that the only difference in students' gain in 'science thinking skills' is explained by their participation in the BrainPop program, and not by gender, class, parents occupation, or participation in extracurricular activities. In other words, students who experienced the use of BrainPop animated movies as part of their science learning, developed thinking skills, such as: science understanding and knowledge implementation, better than their peers in the control group. Eta Squared analysis indicated that 9.3% of the growth in students' science thinking skills can be explained by their use of animated movies.

The comparison of 4^{th} and 5^{th} grade students' levels of explanations showed that the experimental group students (in both class cohorts) had a higher percentage of correct

explanations compared to the control group students. These differences were statistically significant among the 4th grade students ($F_{(623)}$=7.10 p<0.05).

The Effect of Animated Movies on Students' Motivation to Learn Science

The comparison between experimental and control groups in their pre- and post-questionnaires results for each category and general motivation is presented in Table 1.

Table 1. Students' motivation to learn science – experimental versus control, by category

		Pre-questionnaire		Post-questionnaire			
Category	**Research group**	**Mean (1-to-5)**	**Std. Deviation**	**Mean (1-to-5)**	**Std. Deviation**	**F**	**p<**
Self-efficacy	Experimental	3.20	1.04	3.67	0.97	18.16	0.001
	Control	3.07	0.88	3.40	0.95		
Interest and enjoyment	Experimental	3.76	1.29	4.15	0.98	38.03	0.001
	Control	3.45	1.06	3.69	1.08		
Connection to daily leaving	Experimental	3.17	1.04	3.79	0.90	35.50	0.001
	Control	2.92	0.87	3.39	0.94		
Importance to the student	Experimental	3.65	1.10	4.14	0.86	73.87	0.001
	Control	3.27	1.01	3.60	0.91		
General Motivation	Experimental	3.44	0.99	3.94	0.78	53.48	0.001
	Control	3.18	0.76	3.52	0.78		

Table 1 indicates that students who experienced the use of BrainPop animated movies developed higher motivation to study science (in all categories), compared to the control group.

Table 2. Correlation between Students' motivation to learn science and their thinking skills enhancement

Research group	**Variable**	**N**	**Net gain Mean**	**Std. Deviation**	**r**	**p<**
Experimental	Motivation	920	0.56*	1.13	0.21	0.001
	Thinking skills	887	14.82**	26.46		
Control	Motivation	377	0.37*	0.94	0.13	0.05
	Thinking skills	373	5.57**	25.80		

* On a scale of 5 ** On a scale of 100

Table 2 show that in both research groups (experimental and control) statistically significant correlations were found between students' gain in motivation and their thinking skills. However, the correlation between the two variables (motivation and thinking skills) in the experimental group was almost twice as high compared to the control group.

The Effect of Animated Movies on Students' Grades in Science as Reflected in Their Report Cards

The comparison of experimental and control students' grades in science as reflected in their final report cards (Figure 1) indicated that students from both groups received similar grade in science at the end of the year 2008 (around 81.5), but received lower means at the end of the year 2009. This can be explained due to a more severe grading system as the students matured.

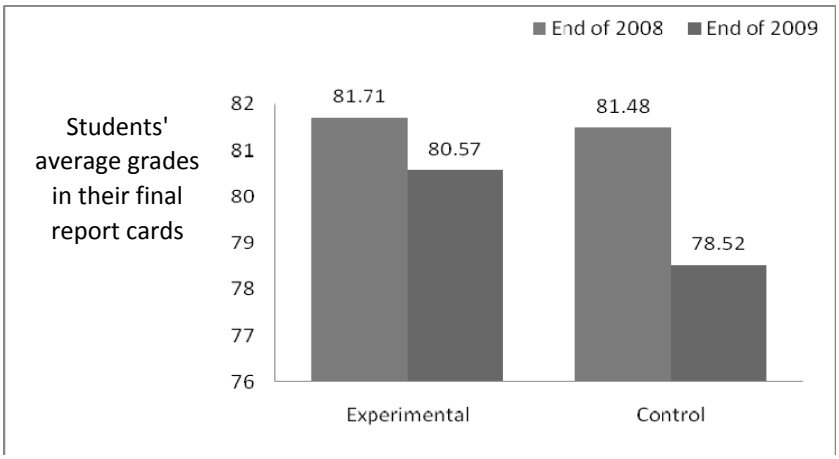

Figure 1. Experimental and control students' average grades in their final report cards

However, students that used BrainPop as part of their science learning received higher grades in their report cards at 91% significance ($F_{(1, 314)}$=2.74, p=0.09).

Summary and Recommendations

Some researchers claim that animations may evoke misconceptions and hinder meaningful learning (Schnotz & Rasch, 2005). The findings of this study and other studies (Dori & Belcher, 2005; Rosen, 2009) indicate quite the opposite. We found that the use of animated movies enhanced students thinking skills, in terms of: science understanding, knowledge implementation, and reasoning ability. Because reasoning ability is necessary for the generation of logical relationships, students that experienced the use of animated movies held les misconceptions than their control group peers. Our study also indicated that students who studied science with the use of animated movies developed higher motivation to learn science, in terms of: self-efficacy, interest and enjoyment, connection to daily leaving, and importance to the student' future, compared to students who studied science in a traditional way.

Mayer's cognitive theory (2002) maintains that knowledge is represented and manipulated through two cognitive channels: the visual-pictorial and the auditory-verbal. Indeed, the animated movies presented in our study had both visual-pictorial and auditory-verbal capabilities. This and the fact that students were engaged in active learning can explain the positive and high correlation between thinking skills and motivation to learn science among the experimental group students. It can also explain the higher grades in science in students' report-cards compared to students who studied in a traditional way.

In light of the positive results described in this research, we recommend to encourage teachers from both science and other disciplines (such as: English, Bible, Literature etc.) to integrate the use of animated movies, along with other educational activities (suggested in the website), more frequently; that is, more than just once a week. We recommend that more animated movies be created for elder users, such as high school and even university students. We also recommend using the website as a platform for creating communities of learners among both teachers and students in Israel and around the world.

It is well known that "a picture is worth a thousand words". In light of the research positive results, we can also say that "an animated movie (that is well presented) is worth a thousand pictures".

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