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Boosting Students' Knowledge of and Attitudes about Science

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Science literacy and academic achievement on science topics empower youth to think critically and understand and apply scientific findings in their daily lives. As youth age into adulthood, their scientific literacy allows them not only to make relatively informed medical, political, economic, and social decisions concerning individual and societal welfare, but it also provides them the impetus to contribute societally through scientific and technological inquiry and advancement (American Association for the Advancement of Sciences, 1993; Miller et al., 1992). One needs only to look at the technological and computing revolutions of the past two decades to understand the importance of promoting scientific inquiry. However, students in the United States perform lower on science achievement tests than many of their international peers (National Center for Education Statistics, 2004). Only 68 percent of fourth grade students perform at or above a basic achievement level. This rate drops to 59 percent by eighth grade and 54 percent by twelfth grade (National Assessment of Educational Progress, 2006). A key question becomes how can teachers, parents, academics, and policymakers in the U.S. improve the science performance of the nation's youth, thereby making them more scientifically literate and empowered to significantly contribute scientifically as adults?

The answers to this question is multifaceted, complex, and nuanced, but some education policy experts argue that students should be provided more class time and class work on science topics. Such approaches may help students know more science, but it does little to help students enjoy science. Indeed, without coupling greater exposure to materials on science with methods to improve students' attitudes about science, such knowledge-building efforts will likely yield limited results. Indeed, while elementary school students report better attitudes toward science than older students, their attitudes decline precipitously as they progress through middle and high school, forming a relatively strong macro-level connection between performance and attitudes. Taken together, there is a need for new approaches that combine knowledge building and attitude development toward science.

Attitude Boost (AB) is one such approach. Funded by the National Institute on Drug Abuse, AB is a multimedia-based curriculum that was developed with input from experts in the education, science, and curricula design fields. AB consists of three components. First is the AB45 Teacher's Guide, aimed at teachers of fourth and fifth grade students so they may provide their students with in-class information that makes science personally relevant by emphasizing the value of science in everyday life. Second is the ABMS Teacher's Guide, which is similar to the AB45 Teacher's Guide but is aimed at teachers of middle school students. Third are student online games that provide materials to review and explore in-class content in more detail.

We evaluated AB through two key studies: a pretest/post-test quasi experimental study to explore the extent to which, among a sample of students, AB increases knowledge and positive attitudes about science and a pretest/post-test quasi-experimental study to explore the extent to which, among a sample of students, exposure to AB before participating in a science-based curriculum on drugs of abuse (Brain Power!) increases knowledge gains related to that science curriculum. In this brief, we report the findings of the first study by examining two key questions. First, to what extent do students exposed to AB

show increased knowledge and more positive attitudes toward science when compared to a control group who were not exposed to AB? Second, how do knowledge and attitude changes vary among fifth graders and eighth graders?

Methodology

To address these questions, we recruited fifth and eighth grade classrooms and assigned them to either an experimental or control group. We exposed students in the experimental group to AB by having their classroom teachers administer it to them. Students in the control group received no exposure to AB. We collected student survey data at two time points, namely, before the experimental group students received the AB exposure (pretest) and after the experimental group students received the AB exposure (post-test). The study included 534 students, of whom 250 were fifth graders and 284 were eighth graders. Taken together, their demographic characteristics suggest that, in both grade levels, students in the experimental group tended to be in higher income households with more educated parents.

To examine knowledge change, we asked each student five questions about science. Each question pertained to a lesson in AB. We asked the students these questions at pretest, that is, prior to the AB intervention for experimental group students, and at post-test, that is, following the AB intervention. We also created a "composite score," ranging from zero to 100, to assess the capacity of each student to answer the questions correctly. To examine attitude change, we asked students in each grade questions about their perceptions of science and their intended futures in scientific fields, which, when taken together, constitute our approach to measure student attitudes. With respect to one's perceptions of science, we asked students to rank the extent to which they agree with the statements, "Science impacts the way I do things" and "Science is important in daily life." With respect to one's intended future, we asked students to rank the extent to which they agree with the statements, "I want to be a scientist when I grow up" and "I look forward to taking more science classes."

Findings

The results on knowledge change are encouraging. As shown in Table 1, among fifth graders, experimental group students, on average, gained significantly more knowledge on three of the five questions than control group students. And overall, on the composite measure, students in the experimental group gained 27.0 percentage points, compared with only 2.2 for control group students. More specifically, experimental group students correctly answered an average a 26.8 percent of the questions about science at pretest, compared with 26.5 percent correct for control group students. After exposure to AB, the average rate of correct answers among experimental group students jumped to 53.4 percent, while the control group students' average rate of correct answers moved only slightly to 28.9. This finding suggests that AB was significantly useful in improving fifth grade students' knowledge on the scientific topics in AB.

The results are also encouraging for eighth grade students. As shown in Table 2, knowledge change improved significantly more for the experimental group on three of the five questions and still experienced a positive, though insignificant change in knowledge on the other two questions. More telling, however, is that the average rate of change in correct answers increased by 14.3 percent for experimental group students, jumping from 35.4 percent to 49.7 percent, compared only 1.3 percent for control group students, a difference that is statistically significant at a greater than 99 percent confidence level. Even when controlling for demographic factors, exposure to AB remains an overwhelmingly significant predictor in the uptick in knowledge on scientific topics.

The results on attitude change are less encouraging. Of the differences on the four measures in the two age groups, only the perception statement, "Science impacts the way I do things" is significantly and positively different between the experimental and control groups among fifth graders (see Tables 3 and 4), a difference that remains significant when controlling for demographic effects. This improved recognition of science as important in daily life is also apparent among eighth graders in the experimental group, though the difference between the rate of change in the experimental and control groups is insignificant.

On every other measure of attitude change, however, the differences in attitude change between experimental group and control group students are insignificant, which likely relates to the short time frame between the pretest and post-test assessments. Indeed, attitude change can take a substantial time. Still, we suspect, though cannot conclude from the data, that AB served as an incubator for attitude change about science and with repeated exposure to it and other "boosting" interventions, students will show greater favorably about science longitudinally. Indeed, when one controls for student demographic characteristics, younger students who were exposed to AB tend to show significantly greater attitude change on at least three measures. Fifth graders were more likely than eighth graders to show a significant increase in their agreement of the statement

"Science impacts the way I do things," "Science is important for daily life," and "I want to be a scientist when I grow up." Fifth graders were also more likely than eighth graders to increase their agreement with the statement "I look forward to taking more science classes," though the finding is significant only at the 90 percent confidence level.

The importance of the exposure to AB as an "attitude booster" is generally confined to younger students, a finding that is reinforced by and positively related to the "likeability" of AB. We asked students in the fifth and eighth grade experimental groups several questions about how much they liked AB and the extent to which they found it interesting and challenging. We transformed their answers into a composite scale, ranging from zero to 100, and found that fifth graders were significantly more likely than eighth graders to describe AB favorably. Indeed, fifth graders gave AB a ranking of 79.2 out of 100.0, compared with 52.7 out of 100.0 by eighth graders. Interestingly, students, regardless of grade level, who did worse on questions about science before the AB intervention and those who improved the most between pretest and post-test were significantly more likely to rate AB favorably. In the end, AB appears to appeal most to younger students who have less knowledge about science, and therefore fewer preconceptions about science.

Implications

Teachers, parents, academics, and policymakers in the U.S. continue to struggle to develop and sustain methods to improve the science performance of the nation's youth, but there also must be a tandem effort to make science more enjoyable for students. It makes sense that students who want to engage in a particular activity – sports, social engagement, arts, humanities – or subject matter – science, mathematics, history – will more likely excel at it, to carry it forward through life, and to pass their positive feelings about it along to others. AB aims to improve attitudes about science and, in some respects with younger students, it achieved that goal. An important follow-up study is to determine the extent that exposure to AB helps to maintain their positivism through sixth grade and beyond.

The question, though, is how to develop interventions for older students that significantly improve attitudes about science. AB fell short on this area, though there are positive elements on which to build. One approach is to use the key tenets and theoretical underpinnings of ABMS in a home-based or extracurricular setting to allow students to pursue attitude-building activities without the involvement of the same classroom teachers whom students may negatively associate with science-based subject matter. One could promote these activities, either through phone or tablet applications or traditional websites, by engaging online mentors to spur older students' inquiry. One could further implement feedback loops to build the content of the apps and websites, creating a universe of materials that drive students' interest in science. In the end, capitalizing on students' creativity and tech savviness is key to promoting their desire for scientific inquiry.

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Table 1. Knowledge change on questions about science, Grade 5

	Experimental			Control				
Question	N	Mean	Std	N	Mean	Std	p-value	Signif.
Classifying tools	122	0.30	0.54	117	0.06	0.46	0.000	**
Scientific inquiry	123	0.50	0.53	116	0.05	0.37	0.000	**
Scientific work cooperatively	122	0.06	0.30	118	0.01	0.31	0.021	
State of matter	123	0.41	0.50	123	0.03	0.28	0.001	**
Methods for investigation	122	-0.02	0.43	120	-0.05	0.45	0.550	
Composite score (percentage)	120	27.00	24.27	108	2.22	17.58	0.001	**

Source: Attitude Boost Data, V1. 2014

Statistical significance: **≤0.001; *≤0.05

Table 2. Knowledge change on questions about science, Grade 8

	Experimental			Control				
Question	N	Mean	Std	N	Mean	Std	p-value	Signif.
Classifying tools	126	0.13	0.52	147	0.12	0.60	0.869	
Scientific inquiry	127	0.25	0.53	149	-0.03	0.43	0.000	**
Scientific work cooperatively	126	0.02	0.35	148	0.04	0.40	0.716	
State of matter	125	0.26	0.44	150	-0.02	0.18	0.000	**
Methods for investigation	126	0.05	0.28	147	-0.05	0.40	0.014	*
Composite score (percentage)	120	14.33	20.11	141	1.27	18.55	0.000	**

Source: Attitude Boost Data, V1. 2014

Statistical significance: **≤0.001; *≤0.05

Table 3. Change in attitudes toward science, Grade 5

	Experimental				Control					
Statement	N	Mean	Std		N	Mean	Std		p-value	Signif.
Perception of science										
Science impacts the way I do things	123	0.19	0.55		126	0.04	0.56		0.028	*
Science is important for daily life	122	0.08	0.47		126	0.10	0.53		0.724	
Personal future in science										
I want to be a scientist when I grow up	122	-0.07	0.42		119	0.02	0.37		0.107	
I look forward to taking more science classes	120	-0.06	0.47		122	-0.03	0.41		0.662	

Source: Attitude Boost Data, V1. 2014

Statistical significance: **≤0.001; *≤0.05

Table 4. Change in attitudes toward science, Grade 8

	Experimental				Control					
Statement	N	Mean	Std		N	Mean	Std		p-value	Signif.
Perception of science										
Science impacts the way I do things	132	0.05	0.52		152	0.01	0.54		0.610	
Science is important for daily life	132	0.03	0.49		152	0.05	0.49		0.221	
Personal future in science										
I want to be a scientist when I grow up	128	0.03	0.38		149	0.03	0.28		0.912	
I look forward to taking more science classes	127	-0.06	0.48		150	-0.13	0.56		0.271	

Source: Attitude Boost Data, V1. 2014

Statistical significance: **≤0.001; *≤0.05

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