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A Preliminary Evaluation of the Effects of a Science Education Curriculum on Changes in Knowledge of Drugs in Youth

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Abstract

Drug and alcohol use among youth remains at pervasively high levels, but students are receiving less school-based prevention. Infusing health information into core curricula may be a valuable prevention approach. Therefore, behavior change theory was used to develop a science education curriculum on drugs for fourth- and fifth-grade students, which was then evaluated using a pretest/posttest quasi-experimental design. Exposure to the curriculum was associated with a change in knowledge; other characteristics like grade level also played a role. More positive attitudes toward science at pretest predicted greater knowledge change, and students who knew less at the start showed a greater change in knowledge. Results of this evaluation may support the efficacy of the curriculum and the utility of combining behavior change theory with educational approaches.

Introduction

Drug and alcohol use among youth has decreased in recent years, but it remains at pervasively high levels. For instance, the 2005 Monitoring the Future Survey found that 41% of eighth graders have used alcohol, and 21% of this age group reports having used an illicit drug (Johnston, O'Malley, Bachman, & Schulenberg, 2006). Although prevalence rates for elementary students are not as well documented, at least one large study reported that 36% of fourth- through sixth-grade students reported having used alcohol, tobacco, marijuana, or inhalants, and 26% of students had used one or more of these substances within the previous year (Wallisch & Liu, 1998).

Youth drug use is a costly public health problem. Youth who use illicit drugs, including alcohol and tobacco, are at a higher risk for negative outcomes, including poor academic performance and increased school drop-out rates (Windle & Wiesner, 2004; Ellickson, Tucker, & Klein, 2003; Ellickson, Bui, & Bell, 1998), early sexual initiation (National Center on Addition and Substance Abuse, 1999; Mott, Fondell, Hu, Kowaleski-Jones, & Menaghan, 1996), perpetration of violence (U.S. Department of Health and Human Services, 2001), and later substance abuse and dependence (Gil, Wagner, & Tubman, 2004; Hawkins et al., 1997; Anthony & Petronis, 1995). On a societal level, the cost of all illicit drug use was estimated to be $181 billion in 2002, which includes the estimated costs related to treatment and healthcare, productivity loss, and the criminal justice system (Office of National Drug Control Policy, 2004).

The risk of addiction is highest in children who start using alcohol or drugs at young ages (Wilson, Battistich, Syme, & Boyce, 2002; Office of Applied Statistics, 2004). In turn, delaying the onset of drug and alcohol use through prevention efforts with youth can prevent future use (see Ellickson, McCaffrey, Ghosh-Dastidar, & Longshore, 2003; Botvin, Baker, Dusenbury, Botvin, & Diaz, 1995; Eisen, Zellman, Massett, & Murray, 2002). Therefore, the National Institute on Drug Abuse (NIDA) and other government agencies suggest that prevention programs should be implemented universally, through schools, and at an early age (NIDA, 2003).

Despite the benefits of school-based drug prevention, a nationwide evaluation showed that the amount of this instruction that children receive has declined significantly from 2000 to 2004 (Orwin, 2006). Indeed, with the implementation of the No Child Left Behind law, students in schools across the country now spend less time on topics such as health and prevention to allow additional time to learn core academic subjects such as math, science, reading, and writing (National Education Association, 2004; Morse, Wilbur, & Ballard, 2004). Although the new educational climate may leave less time for school-based health prevention, there are opportunities to infuse health information into the core curriculum. One such approach is to develop and implement science education-based drug curricula.

Science education differs from prevention in a number of ways. First, science education presents information about effects of drugs on the brain and the body without overt injunctions to avoid use. In a science education curriculum, the content is unvalenced, and drugs are never described as bad or dangerous. Second, science education curricula are matched to state and national standards of learning so they can be implemented in the regular classroom as part of the standard science curriculum. Prevention program are most often implemented in health class or special convocations of students and considered in many school districts to be lower priority than core curriculum subjects such as math, reading and science (National Education Association, 2004; Morse, Wilbur, & Ballard, 2004).

Despite the differences between science education and prevention, the presentation of information in a science education curriculum about drugs may be persuasive and may therefore change attitudes and intentions. Indeed, because there is a negative correlation between the perceived risks of using a drug and actual drug use, an important element of effective prevention is providing information about drugs and their risks (Johnston, O'Malley, Bachman, & Schulenberg, 2005). In this manner, science education can be a type of “stealth” prevention in which students are presented with facts that are likely change their attitudes and behaviors regarding drug use, but not direction to do so.

Against the backdrop of existing research on the negative effects of drug use by youth and recent policy changes that necessitate innovative methods to provide information to them in school-based settings, this article explores the development and preliminary evaluation of a science education-based curriculum on knowledge about drugs of abuse. More specifically, we use data collected from a pretest/posttest quasi-experimental model, whereby fourth- and fifth-grade students in the treatment group were exposed to the curriculum and those in the control group were not in order to address the following empirical questions:

- How did knowledge of science and drugs change from pretest to posttest?
- To what extent does group assignment relate to change in knowledge about science and drugs? In other words, what is the effect of the curriculum on change in knowledge?
- How do other factors, such as positive attitudes toward science and protective attitudes toward drugs, relate to change in knowledge?

- What is the statistical effect of the curriculum on changes in knowledge, when controlling for other key factors, including demographic factors such as grade, gender, and race?

The remainder of this paper discusses the development and theoretical foundation of the curriculum, provides the methodology used its evaluation, describes the key findings of the evaluation, and concludes with the theoretical and practical implications of using a science education-based curriculum for the field of substance abuse prevention in youth.

Development of and Theoretical Basis for a Science Education-Based Drug Curriculum

The curriculum, entitled *Brain Power!* and developed with funding from the National Institute on Drug Abuse, provides students in grades K–8 and their teachers with lessons on the normal functions of the brain, nervous system, and body, and how drugs change these processes. The curriculum was developed through an iterative process, incorporating input from the target audiences of youth and teachers and experts in the field of substance abuse and neuroscience. Moreover, because of the policy push in primary and secondary education to increase the proficiency of students in math, reading, and science, the content of the curriculum was aligned with National Science Education Standards (NSES) and standards of learning from key states such as New York and California (upon which many other states base their standards).

The curriculum covers several types of drugs, including alcohol, nicotine, inhalants, prescription and over-the-counter drugs, marijuana, cocaine, heroin, steroids, methamphetamine, and club drugs such as GHB, MDMA, Ketamine, and Rohypnol. Moreover, the curriculum consists of four separate educational programs, each designed for children in specific grades: kindergarten through first, second through third, fourth through fifth, and sixth through eighth. The curriculum is divided into several age groups because each group has unique developmental and learning needs, and previous research has found that tailored programs are more effective (Oetting, Edwards, Kelly, & Beauvais, 1997; Tobler & Stratton, 1997; Botvin et al., 1995).

Each program includes a range of components, including a teachers' guide, interactive student materials, multimedia and parent materials, and contains individual lessons with specific learning objectives. For example, the fourth- through fifth-grade program—which is the focus of this paper—contains six lessons that were administered to students over a 6-week period. Lessons build on one another cumulatively, where early lessons on the typical functioning of the brain serve as a foundation for later modules on how drugs change that functioning. The specific learning objectives for six lessons are provided in Figure 1. All lessons were field tested with the target audiences prior to initiating the formal evaluation of the curriculum.

Figure 1: Learning Objectives for *Brain Power!* for Fourth and Fifth Grades

Module 1: Students participate in discussion and activities to prompt thinking about drugs and their impact on society. They are asked to think about differences between legal and illegal drugs and what drugs fall into each category, as well as how the media portrays drugs.

Module 2: Students learn about the major parts of the brain, and are asked to give examples of activities that involve the different parts. Students also learn about different techniques used to study the brain, and what each can tell us about the brain and its functioning

Module 3: Students learn about neurons and how they communicate through the process of neurotransmission.

Module 4: Students learn about legal and illegal drugs classified as stimulants (caffeine, nicotine, methylamphetamine (Ritalin), amphetamines, and cocaine), and their effects on the brain and body.

Module 5: Students learn about alcohol, marijuana, and inhalants, and the ways that these drugs affect the body, brain and nervous system

Module 6: Students learn about addiction as a disease resulting from changes in the brain.

The foundation of the curriculum is the Theory of Reasoned Action, which explains the relationship between knowledge, attitudes, and behavior. Exposure to new persuasive information causes progressive changes in knowledge, attitudes, and ultimately behavior (Ajzen, 1991). Research demonstrates that people generally have negative attitudes toward behaviors that they believe will result in negative outcomes (Mykytyn & Harrison, 1993), so the intent of this curriculum is to build knowledge and awareness of the effects and risks of drugs as a precursor to prevention of their use. The theory then suggests that these knowledge gains will translate into attitude, intention, and eventually behavior change.

The Theory of Reasoned Action is commonly used in public health interventions and has a broad evidence base on its proven and potential contribution to effective programs in variety of prevention areas (Fishbein & Yzer, 2003; Sutton, 1998), including injury prevention (Gielen & Sleet, 2003), sexual risk reduction (Albarracin, Johnson, Fishbein, & Muellerleile, 2001), sexual initiation in teens (Dittus et al 2004), gambling prevention (Evans, 2003), domestic violence prevention (Nabi, Southwell & Hornik, 2002) and nutrition education (Alcalay & Bell, 2000). A seminal work on the application of the Theory of Reasoned Action to drug abuse prevention was Fishbein & Middlestadt (1987), and since that time, this theory has been used extensively to understand drug-taking behaviors (i.e. Morrison et al 2002; Norman, Bennet & Lewis, 1998; Petraitis, Flay & Miller, 1995) and as a foundation for interventions to prevent drug use (McNeal et al 2004; Worden & Slater 2004; Amaro et al 2001).

For instance, a school based media campaign for 6th and 7th grade students to prevent drug use was developed using the Theory of Reasoned Action and implemented in school districts in Alabama, Arkansas and Oregon. The goals of this intervention were to increase protective attitudes about drug use, to create more realistic beliefs about rates of drug use in the school population (norms), and to teach refusal skills (Slater & Kelly, 2002). The intervention was an existing prevention curriculum named Allstars^{TM} (Hansen et al 1996), combined with a media component including posters and promotional items branded with the phrase “Be Under Your Own Influence”. The results of this study suggest that students exposed to the intervention were significantly less likely to use alcohol and marijuana than students in the control group (Slater et al 2006). The results of the study were consistent with its foundation of the Theory of Reasoned Action (Slater & Kelly 2002).

Although a mainstay for prevention, the Theory of Reasoned Action is infrequently applied to science education, which instead focuses on knowledge acquisition and application of the scientific process (Bower 2007). However, behavior change theories have been applied during professional development activities for science teachers (Zint 2002; Osterman & Kottkamp, 1993). The integration of behavior change theories into science education for students may be a valuable addition to the field as the opportunities within schools for traditional prevention become increasingly limited.

Therefore, given that the theoretical basis of the curriculum predicts that preventative attitudes and behaviors will flow from knowledge change, the first step of our evaluation of this product is to determine if exposure to the curriculum produces gains in learning. In addition, we were interested in exploring the characteristics of students that benefited most from exposure to the curriculum, as this information may provide pedagogical information on how to best tailor instruction.

Evaluation Approach and Analytic Methods

To assess the efficacy of the curriculum on changes in knowledge about drugs, we collected data from fourth and fifth grades using a pretest, posttest quasi-experimental design. This approach involved assigning 112 students from two schools in the Washington, D.C., metropolitan region by classroom to treatment and control groups. Students in the treatment group received the full curriculum. Those in the control group were not exposed to the curriculum.

Students in both groups received identical surveys with questions pertaining to knowledge and attitudes about drugs before (pretest) and after (posttest) the implementation of the curriculum. The study measure included questions from the following instruments.

Knowledge: A 20-item multiple-choice instrument was developed by the authors to assess children's knowledge about drugs and drug abuse before and after the curriculum intervention. Items directly test knowledge, application, and synthesis of content material in the curriculum.

The How I Feel About Science Questionnaire (HIFAS) (Rim, 1971) was adapted for this study. The HIFAS is a 36-item instrument designed for use in elementary school settings, which measures six aspects of children's attitudes toward science such as attitudes toward science class and attitudes toward science professions.

Attitudes and Intention to Use Drugs: Several instruments with demonstrated reliability and validity for children were modified for this study, including: 1) *Tentative Drug Use Scale* (TDUS) (Horan & Williams, 1975), 2) the *Alcohol Expectancies Questionnaire* (AEQ) (Christiansen, Goldman & Inn, 1982), and 3) *The American Drug and Alcohol Survey* (ADAS: Edwards, Beauvais & Oetting, 1986).

The *Tentative Drug Use Scale* was designed for use in evaluation of drug abuse prevention programs. The *Alcohol Expectancies Questionnaire* is a widely used alcohol expectancy measure in both research and clinical settings. It has well-demonstrated concurrent and predictive validity and has been found to uniquely increase the prediction of alcohol use and abuse. *The American Drug and Alcohol Survey* (ADAS) is a widely used and well-validated scare that measures students' experience with a variety of drugs. Portions of the children's version, designed for third through ninth grade students, were used for this study.

For the knowledge questions, we recorded pretest and posttest answers and determined their correctness. Each student could receive a maximum of 18 correct answers on the survey. We summed the correct answers for each student in the pretest and the posttest and created a measure to determine the amount of change in reporting between the two points in time. We then calculated the mean differences in change scores for the treatment and control groups to create the dependent variable in this analysis.

Questions on the survey also allowed us to create several independent variables that theoretically can predict a change in knowledge about drugs. For example, we used pretest scores to calculate the degree to which the two groups held positive attitudes of science and protective attitudes about drugs, as well as their overall knowledge of drugs, before the curriculum was implemented. These "preexisting" factors, one may theoretically reason, may help to explain some of the variation in knowledge change across groups. Additional independent variables include participation in the treatment group and student-level demographic controls, such as gender, race, and grade. Treatment group participation (yes/no), gender (male/female), and grade (4/5) are measured dichotomously. Race is measured as white, black, and other.

There are data limitations to this study. First, although the curriculum was developed for students in kindergarten through eighth grade, the most comprehensive and current data are available for the fourth- and fifth-grade population. As a result, the generalizability of this study's findings to other school populations should be viewed cautiously.

A second limitation is that a lack of classrooms for control group participation created an unbalance distribution of observations between the treatment and control groups. Indeed, as shown in Table 1, the treatment and control populations vary not only in terms of the number of observations, but also significantly in terms of racial and grade composition. For example, the treatment group has a significantly higher proportion of white students and fourth graders, as well as a significantly lower representation of black students and fifth graders, than the control group. There are no statistically significant differences in gender composition, however.

Table 1.
Demographic Characteristics for Treatment and Control Groups, in Percentages

	Treatment (N=93)	Control (N=19)	
Characteristic	Mean (%)	Mean (%)	Significance
Race			
White	58.1	0.0	**
Black	31.2	79.0	**
Other	10.7	21.0	
Gender			
Male	46.2	36.7	
Female	53.8	63.3	
Grade			
4	60.2	0.0	**
5	39.8	100.0	**

Source: Authors' tabulations of Brain-Power! data.
** p<=0.01

The two groups also vary significantly on certain preexisting attitude and knowledge scores. For instance, students that received the curriculum were significantly more likely to have a positive attitude toward science and protective attitudes toward illegal drugs at the pretest point than the control group (Table 2). However, the treatment group was significantly less knowledgeable about the effects of alcohol and illegal drugs when compared to the control group. The two groups showed no statistically significant variation on protective attitudes about alcohol or nicotine or knowledge about science.

We used a twofold analytic approach to attempt to address the unbalanced groups. First, we ran a set of descriptive statistics that provide the univariate knowledge change within the two groups. Second, we used a multivariate approach to control for the statistical effects of the independent variables noted above. More specifically, we used an ordinary least squares model to calculate the independent effect of treatment group participation on the change of knowledge of drugs, while controlling for other factors. A review of the data suggests that their distribution fail to violate assumptions of an ordinary least squares model. Taken on the whole, this approach yields the following key findings.

Table 2.
Preexisting Attitudes and Knowledge of Treatment and Control Group Participants

	Treatment N=93	Control N=19	
Characteristic	Mean	Mean	Significance
Positive attitudes—science	65.5	32.9	**
Protective attitudes—alcohol	46.4	44.7	
Protective attitudes—nicotine	65.6	58.8	
Protective attitudes—illegal drugs	74.0	62.4	*
Knowledge of drugs	41.9	54.5	**

Source: Authors' tabulations of Brain Power! data.
Note: Cells contain proportional correct answers for attitude and knowledge questions. There were eight possible correct answers for attitudes about science, six possible correct answers for protective attitudes about alcohol and nicotine, and seven possible correct answers for attitudes about illegal drugs. There were 18 questions to ascertain participants' knowledge about drugs.

**p-value <=0.01
* p-value <=0.05

Findings

As shown in Table 3, the fourth and fifth graders in the treatment received, on average, 6.7 correct answers on the 18-question knowledge-based pretest about the effects of alcohol and drugs on the body. Their rate of correct reporting was somewhat lower than 7.5 average correct answers by the control group participants. Looking at these rates proportionally, the treatment group, on average, answered roughly 38% of the knowledge questions correctly on the pretest, compared to nearly 42% group by members of the control group. The difference between the treatment and control group, on average, were not statistically significant at pretest.

After the treatment group received six lessons on the effects of alcohol and other drugs on the brain, both groups were retested, providing the posttest information noted in Table 3.

Unlike the pretest results, the posttest findings show a significant difference between the treatment and control group participants on the 18 knowledge questions. Study participants that received the curriculum answered nearly 10 questions correctly on average, compared with 6.9 for control group members. Put differently, treatment group participants answered nearly 55% of the questions correctly, while those in the control group got, on average, roughly 38% of the questions right. This difference is statistically significant ($p<.01$).

Of particular interest is the difference between pretest and posttest average scores in the treatment and control groups, which provides the chief finding of the study: that is, the implementation of the curriculum in the treatment group appears to play a significant role in changing knowledge of drugs. As noted in Table 3, those that were exposed to the curriculum gained, on average, roughly three correct answers from pretest to posttest, while control group members answered an average of 0.6 more questions incorrectly. Assessing these scores proportionally, youth in the treatment group, on average, performed roughly 17% better on knowledge questions. In contrast, those in the control group performed nearly 4% worse on the posttest.

Table 3.
Mean Scores of Changes in Knowledge about Drugs

Measure of Total Knowledge	Pretest			Posttest			Difference		
	Treatment	Control	P	Treatment	Control	P	Treatment	Control	P
Correct answers	6.7	7.5		9.8	6.9	**	3.1	-0.6	**
% correct answers	37.5	41.8		54.6	38.3	**	17.1	-3.5	**

Source: Authors' tabulations of Brain Power! data
There were 18 possible correct answers for knowledge about drugs
Treatment group: N=93; Control group: N=19

**p-value <=0.01

While these mean differences suggest that the curriculum may have a positive effect on the knowledge of alcohol and drugs among fourth and fifth grade participants in the treatment group, we suspect that some other factors, including demographic and preexisting attitudinal and knowledge differences between the two groups, predict a proportion of the knowledge change. Table 4 shows the results of the ordinary least squares model that assesses the independent effects of treatment group participation on knowledge change, while holding constant additional factors. The results suggest that exposure to the curriculum, even when controlling for gender, race, grade, and preexisting knowledge and attitudes about drugs, is significantly and positively related to knowledge acquisition. In fact, the data suggest that treatment group participation yields roughly 2.5 additional correct answers on the knowledge questions when holding other variables statistically constant.

Table 4.
Determinants of Knowledge Change about Drugs in Youth

Variable	Coefficient	Standard Error	Significance
Treatment group participation	2.54	0.80	**
Gender: male	-0.20	0.43	
Race: white	0.93	0.70	
Race: black	-0.88	0.68	
Grade: 5	2.02	0.48	**
Preexisting positive attitudes—science	0.42	0.13	**
Preexisting protective attitudes—alcohol	0.28	0.28	
Preexisting protective attitudes—nicotine	-0.22	0.21	
Preexisting protective attitudes—illegal drugs	-0.21	0.15	
Preexisting knowledge about drugs	-0.74	0.10	**
Constant	3.50	1.54	*

Source: Authors' tabulations of Brain Power! data.
Adjusted R-square=58.0
N=112

**p-value <=0.01
*p-value <=0.05

But certain other variables tend play a significant role in explaining knowledge change about drugs in the study population. For example, students in fifth grade answer roughly two more answers correctly than do fourth graders, when controlling for other factors (Table 4). This finding suggests that older students may be more willing or capable to absorb formalized information about their effects. It may also suggest that some fourth graders in the treatment did not fully understanding all aspects of the curriculum. More research is needed to determine the difference in correct reporting between fourth and fifth graders on individual questions.

Positive attitudes about science at the pretest phase also correlate significantly with knowledge acquisition. The data suggest that, for every additional unit on the scale of positive attitudes toward science, study participants gain 0.42 more correct answers. This finding suggests that youth who enjoy science may have a stronger incentive to learn about the effects of drugs. In other words, a science-based education may resonate most strongly with youth who feel good about science at the outset. Another possibility is that youth who had preexisting positive attitudes about science are better performing students relative to their peers, which may positively impact their ability to acquire and retain knowledge.

Finally, preexisting knowledge about drugs significantly and negatively correlates with a change in knowledge when holding constant other factors. In fact, the data suggest that, for each additional unit of knowledge about drugs at pretest, students lose 0.74 correct questions on the posttest. We suspect that this finding relates to the fact that children with little information about drugs at the outset of the curriculum actually gain knowledge markedly from pretest to posttest, instead of higher performing youth losing knowledge over time. Indeed, if one interprets the finding somewhat differently, then we can suggest that a lack of preexisting knowledge about drugs positively and significantly relates to positive knowledge change, when controlling for other factors.

Conclusion

Taken as a whole, the data provide some support of the efficacy of one particular science-based curriculum on drugs of abuse for fourth and fifth grade students. Exposure to the curriculum relates to a change in knowledge about alcohol and drugs, and group assignment is a significant predictor of knowledge acquisition, holding constant certain other variables. Nonetheless, other factors played a role in determining knowledge change. Indeed, students in fifth grade showed a greater gain in knowledge than their fourth-grade peers. More positive attitudes toward science at pretest predicted greater knowledge change, and students who knew less at the start of the intervention showed a greater change in knowledge.

Determining which students respond best to this type of science-based intervention provides pedagogical opportunities to tailor implementation of the curriculum for maximum impact. For instance, positive attitudes toward science predict greater knowledge change, and this provides an opportunity to augment knowledge acquisition in students by boosting their opinion of science through field trips, additional instruction, one-on-one mentoring from people in the science field, or a structured group activity. Furthermore, students who enter the program with high preexisting rates of knowledge tend to maintain them, while students at lower levels gain more knowledge, and this suggest ways to best implement the curriculum, such as focusing on smaller, more targeted groups.

To our knowledge, use of behavior change theory to create a science education curriculum is a novel approach toward instruction and prevention. The theory of reasoned action, upon which this curriculum was based, posits that attitude and behavior change flow from knowledge acquisition after presentation of persuasive information. Therefore, outcome data from this evaluation suggest that the curriculum has promise as a component of the core curriculum <u>and</u> as a prevention tool, through its impact on knowledge gain. Although more research should be done, development of an effective educational curriculum from this behavior change theory base may provide new opportunities to infuse prevention into the core curriculum. This integrated approach can allow teachers to provide effective and persuasive health information to their students within a time-constrained classroom. Essentially, this science education curriculum may offer more "bang for the buck"—meeting not only required science content, but serving the purpose of prevention in tandem.

To this end, additional research will further test the behavior change model by using a nested design to examine characteristics of students that show a progression of knowledge, attitude and intention change after exposure to the curriculum, and how these changes may relate to actual risk behaviors in students. Understanding how best practices in behavior change can be integrated into instructional techniques that change knowledge will provide educators and public health personnel effective and realistic tools to transmit information to students. Given the educational climate related to recent federal policies, this integration may mean that more children receive information that results in healthier, more protective behaviors.

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