Educational gaming and afterschool students' science and drug prevention knowledge and attitudes

A program evaluation report for HTF community drug prevention coalition

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Note: This community-based participatory research/evaluation project was done in conjunction with the Heartland Task Force C2000 Substance Abuse Prevention Coalition

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Abstract

The Heartland Task Force C2000 Substance Abuse Prevention Coalition in rural Northeast Missouri purchased laptops for a local afterschool program and enthusiastically conducted a novel intervention for substance abuse prevention education. A digital educational game focused on science and drug prevention knowledge and attitudes was delivered on the laptop computers to at-risk elementary students in the school district's afterschool program. After hour-long sessions for one day every week for six weeks, results of pre-post knowledge and attitude surveys noted the game neither significantly changed participants' knowledge of science and drug prevention nor attitudes toward science and drug prevention. Results of the present evaluation study were inconsistent with other studies using technology in the classroom, possibly due to program delivery in the less formal afterschool setting. Because elementary students' attitudes toward drug use become more pro-use as they get older, consistent teaching about science and anti-drug education both during and after school is needed.

Introduction

The use of technology in K-12 education, especially when used as an educational support or resource, has demonstrated at least small to moderate positive effects on student learning. In a meta-analysis conducted by Lee, Waxman, Wu, Michko, and Lin, the use of technology in the classroom seemed to facilitate content knowledge and positive attitudes, particularly when the embedded tasks are challenging to the student (Lee et al. 2013, 133–146). Although teachers and students perceived technology-supported learning using computers and laptops as motivating and interesting (Godzicki et al. 2013), overall effects on learning outcomes were difficult to determine (Haßler, Major, and Hennessy 2015). In a synthesis, however, improvements in academic achievement in science as well as overall learning development were noted (Zheng et al. 2016).

The use of technology tools like digital educational games on laptops and tablets have become more widespread and considered 'serious' games for training and education. For elementary-aged children, almost half have reported using mobile applications, especially for educational games (Rideout 2013). A recent literature review summarized that using digital educational games can be an effective teaching strategy (Backlund and Hendrix 2013). In other reviews, too, digital educational games improved K-16 student learning when compared to traditional strategies (Clark, Tanner-Smith, and Killingsworth 2016; Wouters et al. 2013); however, they were not more motivating. On the other hand, the effects on student learning have been summarized as limited (Abdul Jabbar and Felicia 2015). When additional instruction supplemented the educational games, though, effect increased (Wouters et al. 2013).

Educational games for science and drug prevention knowledge/attitudes

Science instruction has used digital educational games to support inquiry, problem-solving, and knowledge acquisition. In a review by Li and Tsai, however, most games were focused on student learning of scientific concepts (Li and Tsai 2013). For elementary science students, technology applications in addition to other instructional methods showed promise as an effective teaching strategy (Slavin et al. 2014). Technology and internet access appeared to improve interest and motivation for science among at-risk students (Gillard 2010). In addition, using laptop computers with science learning software for at-risk elementary students motivated the students and individualized their instruction leading to standardized test score improvement (Zheng et al. 2014).

Health instruction has also used digital educational games for health promotion. In an analysis, the games, with broad appeal to all ages and genders, demonstrated minor effects on knowledge and health risks (DeSmet et al. 2014). For example, in one study, a digital educational game with strong learning content was developed for elementary health students. Student motivation and knowledge improved as compared to control (Sung, Hwang, and Yen 2015). Specifically, for the health content area of drug prevention for adolescents, a review suggested that the games can improve student drug prevention knowledge but with limited effect on attitudes (Rodriguez, Teesson, and Newton 2013).

For digital educational games to be most effective for knowledge and attitude change, they must engage the learner so they are cognitively and emotionally immersed in the game. Games should, therefore, include a variety of interactive tools and challenges appropriate to the student's academic ability level, as well as appropriate feedback and support tools that may even include paper-pencil worksheets (Abdul Jabbar and Felicia 2015). In a review by Ravyse et al., guidelines for impactful game production included: backstory, realistic and adaptive interaction, as well as appropriate feedback (Ravyse et al. 2016). BrainTrain4Kids (BrainTrain4Kids n.d.) is a digital educational game designed to educate elementary-aged youth on the science and health topic of drug prevention. Students learn how drugs harm the brain and body using science-based educational lessons housed in interactive, online media 'train stations'. As students enter each virtual train station in sequence on the website, they are introduced to the concepts of: scientific inquiry, parts and functions of the brain, the nervous system, effect of drugs on the body, harmful effects of tobacco use, and how healthy lifestyle can improve brain function. Through interactive activities and games at each train station as well as supplemental printed worksheets and puzzles, positive attitudes and knowledge of science and health are promoted (BrainTrain4Kids n.d.).

Elementary-aged students seem to be aware of alcohol, tobacco and other drugs, are knowledgeable enough to correctly identify many substances, and possess negative attitudes toward use (Hahn et al. 2000). A shift, however, seems to occur as students get older. For tobacco perceptions of upper elementary-aged students in one study, attitudes toward use became less negative as they progressed through the grades. Also, individual's level of belief in the benefits of tobacco usage increased (Freeman, Brucks, and Wallendorf 2005). In addition, in a longitudinal study of elementary-aged students, intention to use substances increased as they progressed through elementary school grades (Andrews et al. 2003).

In a rural Missouri county, the proportion of youth enrollment in free/reduced lunches, child abuse/neglect assessments, and out-of-home placements is higher than the state average (Adair County 2016), and juvenile court placements for parental drug use have increased since 2010 (County Data 2015). The most current 30-day use rates show county youth using cigarettes, alcohol, over-the-counter drugs, hookah, and binge drinking at rates higher than the state average (Behavioral Health Profile 2015). Over half reported friends using alcohol and tobacco in the past year, and that both alcohol and tobacco would be easy to obtain. Average age of initiation for tobacco is 14 years old, and 13 for alcohol (County Reports 2014). The local drug prevention coalition, the Heartland Task Force C2000 Substance Abuse Prevention Coalition, wished to conduct a novel prevention intervention using recently-purchased laptops to interest and engage the at-risk students in drug prevention education.

Because science and drug prevention education have had some success in using technology and digital educational games for learning, and students in a rural county were at high risk for substance abuse problems; the BrainTrain4Kids digital educational game was delivered by drug prevention coalition members. Conducted as a 6-week program (one day each week for an hour), it was held during the regularly-scheduled drug prevention session of an afterschool program for at-risk students in this county. Therefore, the purpose of this study was to determine if the game improved participants' knowledge of science and drug prevention, and if the game improved participants' attitudes toward science and drug prevention.

Methods

Sample

All 77 elementary-aged youth in grades 3-5 enrolled in a school district's afterschool program in a rural Missouri county were asked to participate in this study. Seventy-three (44 girls, 31 boys; all White) of the 75 (97%) participated. No other demographics were collected due to school district policy.

Instruments

As part of the curricular package, the 21-question, paper-pencil BrainTrain4Kids Knowledge Assessment Instrument was used to measure participants' pre-post program science and drug prevention content knowledge. The first 10 multiple-choice questions asked participants to identify the parts of the brain, the next six multiple-choice questions asked about the relationship between using drugs and effects on the brain, and the last five were true-false questions asking about the harmful effects of drugs. All multiple-choice questions included five potential answers and an option of marking "I don't' know". All true-false questions included two potential answers and an option of marking 'I don't' know'.

Also as part of the curricular package, the 16-item, paper-pencil BrainTrain4Kids Attitude Assessment Instrument was used to measure participants' pre-post program attitude toward science and drug prevention. All were Likert-style items to be rated on a scale of NO!=1, no=2, Sort of = 3, yes = 4, and YES!=5. The first 13 questions asked about level of agreement with pro-science and pro-health attitude statements. All 13 questions included an option of "I'm not sure what this question means". The last three asked about how the participant would feel if someone was doing a negative health behavior. All three questions included and option of "I don't understand the sentence" (BrainTrain4Kids n.d.).

Both surveys contained questions aligned with the specific content covered in each of the six train stations.

Procedure

A one-way repeated measure design was used. After Institutional Review Board approval, principal and parent/guardian consent, and participant assent; participants completed the confidential pre-assessments one week before program start during the regularly-scheduled, weekly drug prevention session of the afterschool program.

During the next six regularly-scheduled drug prevention sessions (one day each week for an hour) of the afterschool program, half of the participants were supervised by coalition members as they used laptop computers to navigate the BrainTrain4Kids website. The website consisted of six “train stations” or modules to teach participants about the science behind their brains, bodies, and drugs. During week 1/station 1, participants were shown the steps of scientific inquiry through the use of their senses to describe an object. Week 2/station 2 covered the parts of the brain and brain function. Week 3/station 3 introduced participants to the nervous system using interactive games, followed by week 4/station 4 which covered the harmful effects of drugs on the brain and body as well as why to take medication as prescribed. In week 5/station 5, participants were shown the harmful effects of tobacco on the lungs through a controlled online experiment. During week 6/station 6, healthy lifestyle behaviors were encouraged in order to stay drug-free (BrainTrain4Kids n.d.).

The other half of the group was also supervised by coalition members as participants completed the paper-pencil supportive worksheets and puzzles that accompanied the curriculum. After one-half hour, the two groups switched activities. Each week, the next train station and accompanying worksheets and puzzles were completed by participants. One week after the completion of the program, participants completed the confidential post-assessments also during the regularly-scheduled, weekly drug prevention session of the afterschool program.

Analysis

Responses to knowledge items were coded as correct or incorrect, with correct responses coded with a score of one and incorrect responses a score of zero. All knowledge item scores were then summed to create a total knowledge score for each participant. Possible scores ranged from 0 to 21. The first 13 attitude items included five options that reflected participants' attitudes and an additional option of "I'm not sure what this question means." Responses of "I'm not sure what this question means" were treated as missing data.

Responses reflecting participants' attitudes were coded from one to five with higher scores reflecting attitudes that were more positive. The last three attitude items included three response choices that reflected participants' attitudes and an additional option of "I don't understand the sentence." Responses of "I don't understand the sentence." were treated as missing data. Responses reflecting participants' attitudes on the last three attitude items were coded from one to three with higher scores reflecting attitudes that were more positive. All attitude items were summed to create a total attitude score. Possible scores ranged from 16 to 74.

Two paired samples t-tests were computed to determine if significant differences existed between pre-post knowledge and pre-post attitude scores.

Results

For most knowledge items, participants more often answered incorrectly than correctly for both pre- and post-tests. However, more participants did answer four of the five true/false questions correctly than incorrectly. See Table 1. A paired samples t-test revealed no statistically significant difference between pre-knowledge (M = 8.62, SD = 3.40) and post-knowledge (M = 8.50, SD = 4.49) assessment scores, $t(41) = 0.20$, $p = 0.85$.

For all attitude items on both the pre and post-tests except for one, participant attitudes were more positive than negative. The one item that is the exception is, “People who exercise are cool.” with a post-test mean score of 2.96 (SD = 1.58). See Tables 2 and 3. A paired samples t-test revealed no statistically significant difference between pre-attitude (M = 63.63, SD = 4.86) and post-attitude (M = 63.83, SD = 6.73) assessment scores, t(23) = -0.16, *p* = .87. The lower number of matched sets in the pre-post attitude scores as compared to the knowledge scores is due to response items of “I’m not sure what this question means.” being treated as missing data, which inhibited a total attitude scored from being computed.

Discussion

Science and health education have had some success in using technology and digital educational games for learning. A digital educational game focused on science and drug prevention knowledge was delivered on laptop computers to at-risk elementary students in a school district’s afterschool program by members of a drug prevention coalition. After hour-long sessions for one day every week for six weeks, the game neither significantly changed participants’ knowledge of science and drug prevention nor attitudes toward science and drug prevention.

The use of laptop computers in schools to deliver instructional content has become a popular teaching strategy (Rideout 2013), and science and drug prevention content was delivered to participants in this current study using laptop computers. Although anecdotally, participants were observed by the researchers as enthusiastic about ‘playing the game’ on the laptops, the data indicated no significant changes. The effect of laptops on learning has been noted as positive for science but undetermined overall (Haßler, Major, and Hennessy 2015; Zheng et al. 2016). Laptops were used in the district’s elementary classrooms but have never been used in the afterschool program. Although the use of digital games has been viewed as an effective teaching technique (Backlund and Hendrix 2013), participants in the present study may have been initially enthusiastic about a novel teaching technique in this setting, however, after six weeks; the novelty may have worn off.

Many elementary students are familiar with playing educational games on devices (Rideout 2013). The present study, therefore, used a digital educational game to attempt to change participant science and drug prevention knowledge and attitudes. The use of digital educational games has demonstrated some positive (Backlund and Hendrix 2013; Clark, Tanner-Smith, and Killingsworth 2016; Wouters et al. 2013) but also limited (Abdul Jabbar and Felicia 2015) effects on academic achievement. In regard to science knowledge and attitudes, results of the present study are inconsistent with those of other studies where the use of technology and educational software demonstrated improvements in science knowledge and attitudes of at-risk elementary students (Gillard 2010; Zheng et al. 2014). In regard to drug prevention knowledge and attitudes, results of the present study are also inconsistent with those of other studies that demonstrated some improvements in health knowledge and attitudes (DeSmet et al. 2014; Sung, Hwang, and Yen 2015).

One possible reason for the unexpected knowledge findings is the setting in which the education took place may have not been the best possible learning environment. Participants used the laptops at cafeteria tables in a lobby as others completed their accompanying program worksheets at a group of adjacent cafeteria tables. Such an informal setting may have made participants feel that 'learning' science or drug prevention in the cafeteria was not as important as learning the subjects in the classroom. The true-false knowledge test items dealt specifically with the drug prevention content of the game. Although drug prevention knowledge did not change, more participants answered most of these true-false items correctly. With just two possible choices, participants may have had an easier time obtaining the correct answer. They may have also had an easier time in understanding these questions than the more difficult multiple choice items that included pictures of different sections of the brain to identify. The present study, however, was conducted in an afterschool setting in a community with high levels of substance abuse and poverty that limited its generalizability to other populations. Measurement of a total attitude score was also limited due to treating "I don't know"-type responses as missing data. In addition, with no control group, any change in pre-post-scores could be attributed to learning from the test.

Scores on science and drug prevention attitude items were more positive than negative. Although there was no significant change, participants' mostly positive drug prevention attitudes should be encouraging to the drug prevention coalition. Their level of drug prevention knowledge and attitudes may offer them some protection against health risks in their environment, at least for the present.

Unfortunately, though, as a student progresses through the grade levels, their drug prevention attitudes change to more pro-use (Freeman, Brucks, and Wallendorf 2005; Andrews et al. 2003). It is important to provide quality interventions at early ages to address this trend. Quality digital educational games should be interactive, realistic, and challenging; even including paper-pencil supplements (Abdul Jabbar and Felicia 2015; Ravyse et al. 2016). The intervention used in the present study did follow the guidelines for effective knowledge and attitude change with interactivity, feedback, and support provided. The main science and drug prevention content and application, however, should come from the classroom curriculum and be supplemented in other programs such as afterschool or extra-curricular programs. When used to supplement or coordinated with classroom instructional methods, technology applications are more effective (Wouters et al. 2013; Slavin et al. 2014). It is recommended that digital educational games such as the one in the present study be integrated into the formal classroom setting as an educational supplement as well as used in the less formal afterschool and extra-curricular settings to reinforce that learning. Future programming and research efforts for the drug prevention coalition could examine the impact of this digital educational game in the classroom as stand-alone, and/or integrated with classroom instruction, and/or reinforced in the afterschool setting to determine the best way to integrate it with science and health class lessons.

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Table 1

Pre and Post Correct and Incorrect Response Frequencies to Knowledge Items

Variable	**Pre Test n(%)**	**Post Test n(%)**
You have found a new plant growing outside and you don't know what kind of plant it is. Which one of your senses can you safely use to find out what kind of plant it is?		
Correct		
Incorrect	39(53.4)	41(71.9)
Total	34(46.6)	16(28.1)
	73(100)	57(100)
Which step is “Make a guess or prediction” in scientific inquiry?		
Correct	14(19.4)	10(17.9)
Incorrect	58(80.6)	46(82.1)
Total	72(100)	56(100)
Which step is “Look it over -- use whatever senses you can safely use to find out about it” in scientific inquiry?		
Correct	23(31.5)	12(21.8)
Incorrect	50(68.5)	43(78.2)
Total	73(100)	55(100)
Which step is “Decide what you have learned” in scientific inquiry?	25(35.7)	20(37.0)
Correct	45(64.3)	34(63.0)
Incorrect	70(100)	54(100)
Total		
Which step is “Test or experiment” in scientific inquiry?	25(35.2)	16(29.6)
Correct	46(64.8)	38(73.4)
Incorrect	71(100)	54(100)
Total		

Here is a picture of the brain. What does this part of the brain help you do?		
Correct	1(1.4)	5(8.8)
Incorrect	72(98.6)	52(91.2)
Total	73(100)	57(100)
Here is another picture of the brain. What does this part of the brain help you do?		
Correct	15(20.8)	8(14.0)
Incorrect	57(79.2)	49(86.0)
Total	72(100)	57(100)
Here is another picture of the brain. What does this part of the brain help you do?		
Correct	17(23.6)	11(19.3)
Incorrect	55(76.4)	46(80.7)
Total	72(100)	57(100)
Here is a picture of the brain. What does this part of the brain help you do?		
Correct	9(12.5)	9(15.8)
Incorrect	63(87.5)	48(84.2)
Total	72(100)	57(100)
Here is a picture of the brain. What does this part of the brain help you do?		
Correct	6(8.2)	8(14.0)
Incorrect	67(91.8)	49(86.0)
Total	73(100)	57(100)
Your friend has a new cat. You decide to pet it. When you pet it, you feel how soft the cat's fur is. How do you know what the cat's fur feels like?		
Correct	36(49.3)	32(56.1)
Incorrect	37(50.7)	25(43.9)
Total	73(100)	57(100)
The messages that travel between your brain and your body are partly:		
Correct	9(12.3)	11(19.3)
Incorrect	64(87.7)	46(80.7)
Total	73(100)	57(100)

True or False: Alcohol doesn't do anything to your brain		
Correct	52(74.3)	37(69.8)
Incorrect	18(25.7)	15(28.3)
Total	70(100)	53(100)

Table 2

Frequencies and Measures of Central Tendency for Attitude Items 1-13

Item	**n**	**NO! n (%)**	**no n (%)**	**Sort of n (%)**	**yes n (%)**	**YES! n (%)**	**Mean**	**Std Dev**
I think that science can help me solve problems.								
Pre	64	5(7.2)	2(2.9)	6(8.7)	21(30.4)	35(50.7)	3.56	1.26
Post	50	8(16.0)	2(4.0)	14(28.0)	6(12.0)	20(40.0)	3.56	1.46
I think doing science is fun.								
Pre	67	10(14.9)	2(3.0)	16(23.9)	18(26.9)	21(31.3)	3.57	1.36
Post	52	8(15.4)	2(3.8)	14(26.9)	10(19.2)	18(34.6)	3.54	1.41
I think that learning about science is important.								
Pre	64	3(4.7)	0(0.0)	11(17.2)	11(17.2)	39(60.9)	4.30	1.06
Post	52	5(9.6)	1(1.9)	5(9.6)	9(17.3)	32(61.5)	4.19	1.28

Doing science upsets me.*								
Pre	67	39(58.2)	17(25.4)	7(7.4)	1(1.5)	3(4.5)	4.31	1.03
Post	49	29(59.2)	8(16.3)	7(14.3)	2(4.1)	3(6.1)	4.18	1.20
Science can help me learn about my body.								
Pre								
Post	69	5(7.2)	2(2.9)	6(8.7)	21(30.4)	35(50.7)	4.14	1.17
	50	6(12.0)	1(2.0)	6(12.0)	7(14.0)	30(60.0)	4.00	1.38

I think science is hard to do.*								
Pre	68	18(26.5)	12(17.6)	30(44.1)	4(5.9)	4(5.9)	3.53	1.23
Post	51	21(41.2)	6(11.8)	14(27.5)	4(7.8)	6(11.8)	3.63	1.40
I think that scientists do important work.								
Pre	67	1(1.5)	1(1.5)	3(4.5)	12(17.9)	50(74.6)	4.63	0.78
Post	51	8(15.7)	1(2.0)	5(9.8)	1(2.0)	36(70.6)	4.10	1.53
People who exercise are cool.								
Pre								
Post	63	8(12.7)	7(11.1)	25(39.7)	11(17.5)	12(19.0)	3.19	1.24
	48	16(33.3)	1(2.1)	11(22.9)	9(18.8)	11(22.9)	2.96	1.58
I think exercise is fun.								
Pre								
Post	69	8(11.6)	2(2.9)	18(26.1)	14(20.3)	27(39.1)	3.72	1.33
	50	7(14.0)	1(2.0)	12(24.0)	8(16.0)	22(44.0)	3.74	1.41
Smoking cigarettes can be helpful to your body.*								
Pre								
Post	67	61(91.0)	4(6.0)	1(1.5)	1(1.5)	0(0.0)	4.87	0.49
	51	44(86.3)	1(2.0)	0(0.0)	0(0.0)	6(11.8)	4.51	1.30
Smoking cigarettes is good for your health.*								
Pre								
Post	69	62(89.9)	4(5.8)	1(1.4)	0(0.0)	2(2.9)	4.80	0.74
	50	46(92.0)	1(2.0)	0(0.0)	0(0.0)	3(6.0)	4.74	0.86
Drinking alcohol can be harmful to your body.								
Pre								
Post	69	4(5.8)	1(1.4)	9(13.0)	9(13.0)	46(66.7)	4.33	1.13
	49	6(12.2)	0(0.0)	1(2.0)	3(6.1)	39(79.6)	4.41	1.34

Drinking alcohol can be harmful to your brain.								
Pre	65	2(3.1)	0(0.0)	8(12.3)	10(15.4)	45(69.2)	4.48	0.34
Post	67	6(12.8)	0(0.0)	4(8.5)	2(4.3)	35(74.5)	4.28	1.39

Note: 5 = YES!; 4 = yes; 3 = Sort of; 2 = no; 1 = NO!

*Denotes items that were reverse coded.

Table 3

Frequencies and Measures of Central Tendency for Attitude Items 14-16

Item	n	Not at all worried n (%)	Little worried n (%)	Very worried n (%)	Mean	Std Dev
If someone I knew exercised every day, I would feel:*						
Pre	63	43(68.3)	16(25.4)	4(6.3)	2.62	0.61
Post	42	28(66.7)	12(28.6)	2(4.8)	2.62	0.58
If someone I knew was smoking cigarettes, I would feel:						
Pre	66	4(6.1)	10(15.2)	52(78.8)	2.73	0.57
Post	42	1(2.4)	8(19.0)	33(78.6)	2.76	0.48

If someone I knew drank a lot of alcohol each day, I would feel:						
Pre	66	3(4.5)	5(7.6)	58(87.9)	2.83	0.48
Post	40	3(7.5)	3(7.5)	34(85.0)	2.28	0.58

Note: 1 = Not at all worried; 2 = Little worried; 3 = Very worried

*Denotes items that were reverse coded