Learning the Science behind Drug Addiction: A School-based Laboratory Approach to Addiction Prevention

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Abstract

The purpose of Science Education Against Drug Abuse Partnership (SEADAP) is to use the planarian animal model to develop an inquiry-based program to teach the science of drug addiction and pharmacology of drugs being abused. Upon completion of a SEADAP teacher professional development, study data reveals a favorable increase in teacher awareness of careers related to biomedical research, knowledge of the hazards of using addictive substances, knowledge about the science of drug addiction and skills related to the use of animals in scientific research. Additionally, SEADAP supported professional development (PD) for teachers is of high quality, relevant to their needs, and meets their expectations in providing important resources for teaching and learning. SEADAP teacher participants gain relevant knowledge about drug addiction and abuse to incorporate it into instruction about the scientific process. Teacher SEADAP participants administered a pretest to middle school students prior to SEADAP-related instruction and a posttest was administered to student participants after SEADAP-related instruction had concluded. Student mean posttests scores on knowledge about drugs, biomedical careers and animal model research significantly increased from pretest scores. This indicates that the implemented lessons of the SEADAP teachers impact students.

Introduction

In 2011, the estimated cost of illicit drug use to the United States (US) economy was $193 billion (National Drug Intelligence Center, 2011). Healthcare costs associated with both alcohol and tobacco abuse was estimated at $150 billion per year. In addition to this strain on The United States financial resources, the medical consequences of drug addiction have been associated with furthering the progression of brain disease (Aggarwal, Sian & Levine, 1998). Some of the resulting neurological medical issues associated with this disease include, stroke, seizures, paranoia, depression and aggression (National Institute on Drug Abuse, 2012). Persons addicted to any number of drugs may also resort to crime including assault, burglary, identity theft and domestic violence, and these crimes cost the criminal justice system over $61 billion dollars per year (Mumola & Karberg, 2006; National Drug Intelligence Center, 2011).

Drug addiction statistics reveal that approximately $7 billion has been spent in the United States on drug education and prevention programs (Griffith & Scheier, 2013; Kim, Colleti, Crutchfiled, Williams & Hepler, 1995; Ruuska, 2012). Currently, 6th-12th grade school drug abuse and prevention programs simply provide students with information about addiction and commonly abused drugs. The purpose of programs such as Define Assess Respond and Evaluate (DARE), Project Alert, Positive Action, and Keepin' It Real, offer information and education to dissuade students from using drugs (Clayton, Leukfeld, Harrington, & Cattarello, 1996, Ennett et al., 1994; Hecht & Miller-Day, 2010; Lewis et al., 2013; Lynam et al., 1999; Rand Corporation, 2016). While the effect of these programs on curtailing drug use is continuously being evaluated (Ringwalt et al., 2011), these drug abuse education programs provide limited, if any, information to students regarding the pharmacology of drugs being abused and even fewer promote conducting responsible research with live animals pointing to the effects of drug abuse.

The effects of addictive substances have been traditionally studied using mammals (i.e., humans and rats) in research labs such as pharmaceutical labs, government research agencies and medical facilities. The use of mammals in 6th -12th grade classrooms can be a challenge to maintain and a great expense (Department of Comparative Medicine: Animal Care Husbandry, 2014). Studies, however, do point to the use of simpler organisms such as planaria to understand behaviors associated with drug abuse (Rawls, Patil, Yuvasheva, & Raffa, 2010).

Science Education Against Drug Abuse Partnership Program

To overcome the impracticality of experimentation with mammals in the classroom laboratory, the Science Education Against Drug Abuse Partnership (SEADAP) program incorporates the use of planarians, also termed aquatic flatworms, as a less expensive but effective strategy to engage students in the study of drug addiction and abuse. Within the SEADAP program, teachers and

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students engage in lessons and strategies which involve the use of planarians that mimic mammalian-like neuro-transmitter systems that are targeted by addictive substances. Teachers learn through experimental investigations on the pharmacological effects of drug abuse in planarians, which in turn supports their students in the study of key facets of addiction which include withdrawal, anxiety and place preference conditioning, each of which are highlighted within the educational materials developed by the SEADAP program. For full detailed lessons refer to http://planarianparty.com/docs/PlanarianParty_LessonPlans.pdf

Goals

The purpose and broader impact of the SEADAP program is for students to learn about drug addiction and the adverse affects of widely abused drugs and conduct inquiry-based investigations using planaria. The proposed goals of SEADAP are to develop and implement an inquiry-based program to teach the pharmacology of drug addiction to students and to expose middle and high school students to drug addiction research. The goals of the program during the first year were to increase: 1) knowledge about the science of drug addiction, 2) knowledge about biomedical careers, and 3) understanding about how animal models are used to advance knowledge about medical research.

Research Questions

This study addresses the following research questions: 1) To what extent did SEADAP provide high quality PD for the participating teachers? and 2) To what extent did the participating teachers in SEADAP transfer the goals of the program to their own teaching and learning environments?

Theoretical Framework

According to Quigley (2014), best teaching practices in science education include student participation in investigative activities which go beyond traditional "cookbook" laboratory procedures. Likewise, Schneider, Krajcik and Blumfield (2005) point to professional development for science teachers in transforming science instruction from a "telling" to a "doing" experience. These ideas are advocated by the American Association for The Advancement of Science. AAAS (1993) and National Resource Council (2000) which both promote changing instruction to optimize student learning of science to promote scientific literacy. While inquiry is not a new idea embedded in the *Benchmarks for Science Literacy* (AAAS, 1993), it remains critical to reform-based teaching in science education. Science education reform efforts involve incorporating inquiry-based instruction and have served to shift the focus of science instruction to include greater student participation in the culture of the scientific community and immerse students in real-world experiences. Lave and Wenger (1991) refer to this as a learning that goes beyond acquisition of facts, but embeds the practice and problem solving in the full social context of the learning event taking place. This shift in focus from rote memorization of scientific facts to protocols designed to support the development of student understanding of scientific concepts and the inquiry process has the potential to motivate students toward further study in all fields of science.

Additionally, greater learning outcomes are realized when students are afforded the opportunity to associate science with solutions to real world problems which are relevant to them in meaningful ways (Huang, Chiu, & Hong, 2016). As students experience the culture of scientists and engage in practices that provide opportunities for authentic learning, the academic language of the scientists eventually becomes the language of the student. The student develops an understanding of and familiarity with science and can begin to apply scientific principles outside the classroom.

To further assist in the development of authentic learning environments for students, teachers should participate in high quality professional development (PD) that includes the best instructional practices aligned with state and national standards to improve student education (Capps & Crawford, 2013; Geier et al., 2008; Lieberman & Wehlburg, 2002; Little, 1993; Talbert, McLaughlin, & Rowan, 1993). High quality PD can be initially delivered in a few hours or days however, in order to be meaningful and sustainable, it must be ongoing with follow-up in the months that follow the PD (Wei, Darling-Hammond, Andre, Richardson, & Orphanos, 2009; Velardi, Folta, Richard & Kuehn, 2015). Further, high quality professional development sessions in science education should be designed to offer practical strategies that will later be incorporated into teaching and learning that is relevant to students and promotes exploration in to employment needs in science-related fields (Garret, Porter, Desimone, Birman & Yoon, 2000; Lieberman & Wehlburg, 2002; Little, 1993; Talbert & McLaughlin, & Rowan, 1993). Moreover, high quality PD should allow teachers to collaborate and discuss strategies to implement lessons for students to understand scientific concepts and processes through real world experiences (Capps & Crawford, 2013; Furtak, Seidel, Inverson, & Briggs, 2012; Geier, et al., 2008; McComas & Jiang, 2015; Miles, Slagter van Tryon, & Moore Mensah, 2015). Therefore, high quality PD in science education that is designed and developed for hands-on, inquiry-based authentic learning affords teachers the opportunity to participate in a type of embedded learning in which their students will later engage. According to Tretter and Jones (2003), students engaged in inquiry-based lessons were more likely to have higher attendance in school, show up to take tests, and have a positive attitude about science. Archer and Ng (2016) reported that incorporating the scientific method and inquiry-based strategies, even in the mathematics classroom, allowed students to make predictions and conclusions related to solving problems in real time.

The management of the classroom learning environment in science education is also a key component of high quality PD (Catalano, 2010; Roffey-Barentsen, 2011) and is consistently considered in the SEADAP program development. This includes methodologies to organize students to conduct inquiry-based activities in collaboration with trained teachers and assistants. High quality PD should also incorporate teacher familiarity with assigning student roles and responsibilities to complete group work, student pairs, and whole class group learning tasks (Catalano, 2010; Hsiung, 2012). Careful selection of role assignments for student pairing and small group activities promotes successful collaboration by having students accountable for learning, developing team interactions, and enhancing negotiation during problem solving events. Students working in pairs and groups have the opportunity to engage in continued interactions with peers, as well as share written and oral reflection of their understanding of scientific concepts and content. Additionally, they learn to not rely solely on the instructor to facilitate the learning event (Catalano, 2010; National Center, Quality Teaching and Learning, the Office of Head Start, 2012).

Methods

The SEADAP research scientist and science education researcher lead the SEADAP professional development (PD) session for participating teachers. During the PD, teachers participated in demonstrations in inquiry-based, hands-on investigations to lead their own students in the design of experiments using planarians for drug abuse studies. Participating teachers were provided with lessons that address the Next Generation Science Standards, National Science Education Standards, and Common Core Essential Standards. This PD introduced teachers to biomedical research protocols, research ethics, planarian animal model, analysis of drug addiction research, and methods of analysis of research. The PD consisted of a four-day teacher participant training during the academic year and totaled 32 contact-hours.

Setting and Sample Population

SEADAP Professional Development sessions were conducted at two major universities in North Carolina (NC) and Pennsylvania (PA). The program was designed as a four-year project for teachers and students. The current study focuses on outcomes for SEADAP professional development for teacher participants in NC during year one and the resulting impact of the SEADAP program on participating teachers' students.

Teachers

Teacher participants were recruited from two school districts in NC during the summer prior to the academic year in which they were to implement SEADAP lessons. Numerous strategies were used to recruit participating teachers including SEADAP staff appearance on a local news show and flyers advertising the program sent to targeted school districts, superintendents, principals, department chairs, and science teachers. Presentations were made at conferences to motivate teacher participation, and written announcements were also posted in newsletters and professional development workshops sponsored by state and national science education organizations. Science teachers were also telephoned and sent emails to motivate interest to participate in the SEADAP program. The PD included sessions led by key SEADAP staff members, state-level politicians, STEM faculty at a university in NC, and local biomedical researchers. Teachers (n= 10) were all instructors at the middle school level and had an average of 10 years teaching experience. The majority were female **(n= 9)** with one male participant. Seventy percent were White and 30% Black. Teachers were paid a stipend as an incentive to participate in SEADAP, as supported by Mclean and Van Wyk (2006).

Students

All NC students were in grades 6-8 from two public school districts and were the students of the 10 SEADAP teacher participants. **Of a total of 304 participating students,** approximately 52% were female (n=158) and 48% (n=146) were male. Two percent (n=5) were American Indian /Alaska Native, 1% (n=4) were Asian, 38% (n=114) were Black or African-American, 10% (n=29) were Hispanic/Latino, 34% (n=103) were White, and 15% (n=46) indicated **multiple ethnicity/race group**. Three students did not indicate ethnicity/race.

Research Design

The research design included both qualitative and quantitative methodologies. One of the program evaluation instruments, the Professional Development Questionnaire (PDQ), was developed and validated by the SERVE Center. The SERVE Center is a regional educational research and development organization that is well respected for evaluation of STEM and instructional technology projects. Questionnaire items were examined by multiple parties (SERVE representatives and researchers) revised and edited through an iterative process to achieve face validity consensus that the items were appropriately stated for collecting data to measure what the PDQ intended. The PDQ contained Likert scale type items based on data sought from teachers' awareness of science-related careers (particularly biomedical careers); knowledge of the hazards of using addictive substances; knowledge about the science of drug addiction; skills related to the use of planarians in basic science research. The Cronbach's alpha, a measure of the internal consistency for the eight item Likert statements on the PDQ, was 0.81. Formative data was collected on perceptions of whether the program was of high quality, relevant to teacher needs, provided important resources, and whether the program met expectations. The PDQ also included open-ended response items to gather data pertaining to the most and least useful aspects of the SEADAP professional development.

Pretests and Posttests

The pretest and posttest instruments were developed by SEADAP researchers in collaboration with the SERVE Center to assess student knowledge related to the program goals. Pretests and posttest items were examined by SERVE representatives, SEADAP researchers, and NC teacher participants of SEADAP to again address face validity and to measure the extent the SEADAP program accomplished the goals of the program. A pretest instrument was administered to students of teacher participants prior to SEADAP-related instruction. An identical posttest was administered to student participants after SEADAP-related instruction had concluded. The pre/posttest instrument items addressed Goal 1 (items 1, 2, 3, 4, 5, 6, 7, 8 and 9), Goal 2 (items 10 and 13) and Goal 3 (items 11 and 12) - see Appendix C. Three hundred eighty-four students took the pre or posttests. Of these 384 students, 304 completed both the pre and post-tests which were explicitly matched for analysis.

Observations

The SERVE evaluators used an observation protocol designed specifically for the SEADAP program and observed at least one class period (which ranged from 50 to 90 minutes) in which students of teacher participants were conducting experiments with planaria (i.e., stereotypy, motility, chronic drug exposure, and place conditioning). The observation protocol was designed by SERVE with input from the SEADAP researchers. The observations were not intended to judge nor rate teacher performances in any way, but instead to help identify challenges and/or successes that emerge as students increase their knowledge about biomedical research and gain knowledge relevant to conducting SEADAP-related experiments in the classroom. To support further validity evidence, qualitative data from the observation protocol was hand coded (Patton, 2002) and analyzed using the constant comparative method, an iterative process of coding qualitative data or recurring themes (Merriam, 2001) by SEADAP researchers. Inter-rater reliability was present among SEADAP researchers as achieved in reporting emergent themes from qualitative data analysis.

Focus Group Sessions (FGS)

Focus Group Sessions (FGS) were also conducted near completion of the PD to assess teacher perceptions of their learning experience. To decrease bias, FGS were conducted by SERVE staff and not by the SEADAP researchers, with each session lasting for approximately 45 minutes. Before implementation, FGS were conducted face-to-face with teacher participants (n=10) near the completion of the PD.

The *after implementation* FGS were conducted via Google Hangout video conference with teachers (n=6). Teachers were asked two questions: 1) what were the most successful aspects of implementation? and 2) what were the most challenging aspects of implementation? FGS were analyzed by SEADAP researchers. Qualitative analyses were conducted using a constant comparative method, an iterative process of coding qualitative data for recurring themes (Merriam, 2001). Researchers were cautious during the analysis process to report emergent themes grounded in data (Patton, 2002).

Results

To address the research question: to what extent did SEADAP provide high quality PD for the participating teachers? Teachers were asked to complete the PDQ regarding their professional development experience at the conclusion of the workshop sessions. As seen in Table 1, responses were based on a five-point Likert scale (SA=strongly agree, A=agree, N=neutral, D=disagree, and SD=strongly disagree). Teachers reported (mean scores ranged from a low of 4.30 to a high of 4.70) the PD sessions increased their awareness of science-related careers (particularly biomedical careers), increased their knowledge of the hazards of using addictive substances, increased their knowledge about the science of drug addiction, increased their skills related to the use of planarians in basic science research, were of high quality, were relevant to their needs, provided important resources, and met expectations.

Teacher participants were also asked to respond to open-ended questions on the PDQ about what were the most and least useful parts of the PD. Based on content analysis of open-ended questions on the questionnaire, the following components were considered the most and least useful parts of the PD opportunities provided.

Most useful:

- Knowledge gained about drug addiction and effects of addictive substances
- Availability of resources to assist with implementation of SEADAP lessons
- Collaboration with other teachers to plan SEADAP-related instruction
- Access to researchers and staff to answer questions related to the development and implementation of lessons.

Table 1. Professional Development Questionnaire (PDQ)

	5 SA	4 A	3 N	2 D	1 SD	*Mean*
1. Increased my awareness of STEM careers (particularly biomedical careers).	60%	40%	–	–	–	4.60
2. Increased my knowledge of the hazards of using addictive substances.	50%	40%	10%	–	–	4.40
3. Increased my knowledge about the science of drug addiction.	40%	50%	10%	–	–	4.30
4. Increased my skills as they related to the use of planarians in basic science research.	60%	40%	–	–	–	4.60
5. Was of high quality.	40%	60%	–	–	–	4.40
6. Was relevant to my needs.	40%	60%	–	–	–	4.40
7. Provided important resources for me.	70%	30%	–	–	–	4.70
8. Met my expectations.	40%	60%	–	–	–	4.40

Least useful:

- Skype and video lectures did not have a human connection
- Some lunchtime speakers were perceived as presenting irrelevant information
- Limited opportunities to do hands-on experiments
- Unavailability of pretest to guide lesson plan development
- Some of the content knowledge was too in depth for students

The researchers and SERVE reconciled any inconsistencies. If any teacher response did not align to the question then responses were dropped.

To address the research question: to what extent did the SEADAP participating teachers transfer the goals of the program to their own teaching and learning environments? Paired sample t-tests were conducted to determine if there was a significant change for student pre and post test scores (see Tables 2 and 3). Pretest and posttest scores for the total number of student participants (N = 304) comparison indicated that the mean pretest score was 5.27(SD=2.13) and mean posttest score was 7.09 (SD=2.99). A significant increase from pretest posttest was found (t (303) = -10.939, p <0.001). Upon further analysis it is interesting to note that a paired sample t-test was conducted and significant increases from pretest to posttest were found for the students by teacher. For teacher 3 the mean pretest student score was 5.07 (SD=2.05) and mean posttest score was 11.06 (SD 1.50). A significant increase from pretest to posttest was found (t (53) =-19.227, p <0.001). For teacher 7 the mean score of the pretest was 5.73 (SD = 2.33), and the mean posttest score was 7.05 (SD = 2.92). A significant increase from pretest to posttest was found (t (61) = -3.73, p <0.001). No significant differences were found for the remaining student scores by teacher mean pretest and posttest scores. There were also no significant differences for the students of the SEADAP teacher by ethnicity or gender.

Table 2. Paired Sample t test All Students

Pretest			Posttest					
N	M	SD	N	M	SD	t	df	*p*
304	5.27	2.13	304	7.09	2.99	-10.939	303	**0.000***

Observations

Observations of the teachers were analyzed and coded by the researchers and SERVE. Themes pertaining to challenges and successes emerged. The following challenges were perceived by the teacher participants for the students.

- Off task behavior
- Time to complete an experiment
- Unwilling to design their own experiment
- Planarians dying
- Unfamiliarity with the scientific method
- Mathematics calculations

Teacher participants were able to provide student instruction related to the SEADAP curricula in the classroom and were observed successfully:

- Grouping (2-3 students) to complete laboratory investigations
- Implementing afterschool program with small of group of students (fewer than 10)
- Incorporating the scientific method
- Providing written materials for students to read to implement laboratories
- Writing laboratory procedures prior to implementation
- Assisting students with conducting laboratories by adult volunteers

Teachers faced challenges and successes during the implementation of the SEADAP curricula within their student learning environments. Timing allocation issues in conducting experiments and familiarity with science and mathematics content/concepts were major challenges for students. However, assisting groups of students with the writing and implementation of the experiments was observed as successful.

Before Implementation Protocol: Near the completion of the PD all ten NC teachers were asked to discuss their experience *before implementation* of SEADAP lessons with students. Constant comparative method was used (Merriam, 2001), and seven themes emerged: 1) Relevancy of topic 2) Knowledge about the topic 3) Comfort with implementation 4) Knowledge about scientific process 5) Student engagement 6) Issues with implementation 7) Program focus.

During Implementation Protocol: All NC SEADAP teachers provided their students with instruction about the anatomy and movement of planaria. In all teacher classroom settings students were observed working in pairs or in groups. Teachers were required to implement two lessons which included the use of planaria and the substances caffeine,

Table 3. Paired Sample t Test Teacher

	Average number correct								
	Pretest			Posttest					
	N	M	SD	N	M	SD	t	df	*p*
1	20	5.25	2.17	20	6.45	2.30	-3.093	19	0.006
2	23	5.48	2.17	23	6.17	2.08	-2.006	22	0.057
3	54	5.07	2.05	54	11.06	1.50	-19.227	53	**0.000***
4	35	5.54	2.31	35	6.29	1.98	-2.752	34	0.009
5	72	5.03	2.03	72	5.58	2.48	-2.333	71	0.022
6	38	4.87	1.83	38	5.97	2.28	-3.53	37	0.001
7	62	5.73	2.33	62	7.05	2.92	-3.73	61	**0.000***

alcohol, sucrose or nicotine. The lesson investigations were noted to incorporate stereotypy, motility, chronic drug exposure, anxiety, withdrawal, or place preference conditioning.

Focus Group Session

After Implementation: During Focus Group Session (FGS) via Google Hangout (n=6), teachers were asked to describe their successes and challenges associated with the implementation of their SEADAP curricula. The video session was approximately 45 minutes. Various challenges were consistently reported and there were a few challenges discussed. Limited knowledge about using planarians in SEADAP experiments were difficult for both the teacher participants and their students. Snow days were an obstacle which delayed plans to use planarians in the classroom. Planarians would be delivered to school and, as result of school cancellations due to inclement weather, upon return to school the planarians would not be viable to use. Additionally, teachers commented that they did not know what to expect when facilitating laboratory investigations using planarians in prescribed drug environments. This uncertainty made the teachers feel uncomfortable, especially when students would seek confirmation of results. One teacher said that one of her three classes was unable to focus on SEADAP activities, and therefore decided not to implement SEADAP investigations with that particular class. Finally, one teacher reported that implementing SEADAP lessons in a 50-minute period was a struggle and would strongly recommend carrying out investigations with middle school students during 90-minute block schedules.

In spite of reported challenges, there were several successes related to the implementation of SEADAP lessons. One teacher incorporated the use of microscopes for the first time, and another invited a guest speaker to the class to share expertise about drug addiction. In addition, one teacher was able to connect SEADAP curricula to other health and drug prevention programs occurring at her school. Similarly, one teacher noted that SEADAP instruction allowed students actually to see the effects of drugs, such as nicotine on planarians which expanded the experience beyond the "just saying no" often found in existing drug prevention programs.

Discussion

This study reports preliminary findings addressing research questions for the first year of the four-year SEADAP project for middle school teachers and students. NC teachers responded favorably regarding their participation in SEADAP. Study data revealed that upon the completion of the PD, a resulting increase was reported in teacher awareness of careers related to biomedical research, knowledge of the hazards of using addictive substances, knowledge about the science of drug addiction, and skills related to the use of planarians in scientific research was achieved. Teacher participants reported that the PD was of high quality, relevant to their needs, met expectations, and provided important resources. Data collected from open-ended questions mirrored FGS findings. Teachers gained relevant knowledge about drug addiction, the effects of substance abuse and how to incorporate what they learned into the instruction of the scientific process.

Drug prevention programs assist with learning emotional and developmental skills to engage in social environments, to lessen risk-taking behaviors associated with drug abuse, to debunk misinformation about drug addiction or abuse and to provide information about drugs currently being abused (Olsson & Fritzell, 2015). The underlining resolve of teacher participation in SEADAP is to deter student use of illicit drugs which, have adverse health effects, and to lower criminal activity (Mumola & Karberg, 2006; National Drug Intelligence Center, 2011; National Institute on Drug Abuse, 2012). Examining a change in student attitudes, possibly via reflective journals, about the consequences of drugs of abuse is also a focus of the SEADAP program and will continue in future study. Current research advocates having students engage in meaningful activities in programs like SEADAP which link science to aspects of health risks associated with illegal drug use as a key component in education (Grace, Woods-Townsend, Griffiths, Godfrey, Hanson, Galloway, Inskip, 2012). The hope is to promote informed decision making for healthy choices when presented with situations where potentially addictive drugs are within a student's reach.

Future work and conclusion

While a number of studies have examined drug prevention programs in terms of student growth in engagement and desired outcomes (Hanson, Fleming, & Scheier,2019; Pettigrew, Graham, Day, Hecht, Krieger, & Shin, 2015), the SEADAP program was particularly successful in increasing content knowledge in biological processes that result from drug abuse. When examined closely, the facilitated inquiry learning approach investigated the effects of different concentrations of sucrose, caffeine, nicotine and alcohol on living organisms, proved relevant and sustainable cognitively. As noted, a significant increase in achievement on student posttest assessments related to competencies in biological processes were realized. In a range of pointed test items, biological processes were examined from evaluating the brain's reward system to the brain neurotransmitters specifically. The student survey instrument was two-fold in both examining change in student content knowledge, as well as aligning with Next Generation Science Standards related to biological processes. Inquiry learning through the SEADAP program provided the opportunity for students to apply new competencies to predict change from brain altering substances.

In light of the current study findings, real time and relevant analyses of observable data from substance interactions on live organisms promoted opportunity for students to engage in well-informed conclusions about the effects of drug abuse through evidence gained in their own laboratory observations. This situated learning experience will remain the focus of future study into motivation and ultimately behavioral change as a result of SEADAP lessons. Cause and effect relationships examined here, and as a basic tenet of inquiry science, will continue to afford learners in the program the opportunity to consider the dangerous impact of abused substances on the human brain.

Future research will present further classroom observation data of SEADAP lessons in both NC and PA school systems and will communicate a detailed narrative focusing on the benefits of the program. Future work will also continue to involve students in designing and performing scientific investigations related to SEADAP instruction, and an abundance of hands-on inquiry lessons will be included in future SEADAP workshops (Capps & Crawford, 2012). In addition to having teachers administering pretest and posttest instruments, student participants will be required to write a reflection to assess the accomplishment of meeting the goals and expectations of the program.

According to Herrington, Parker, and Boase-Jelinek (2014), having students reflect on new information learned supports the key component of authentic learning within this form of a laboratory learning environment. A student reflective journal can be used to inform the educator about whether goals have been met. In particular, reflective journals can provide insights from students' perspective about the learning journey and knowledge gained about drug addiction and drug abuse.

The SEADAP program is continually making strides to achieve the goals of the project. The significant difference in the pretest and posttest scores which addressed the goals of the program indicate that the implemented lessons of the SEADAP teachers did impact their students. More specifically, incorporating inquiry-based learning into instruction can increase knowledge about drug addiction, biomedical careers and how animal models are used to advance knowledge about biomedical research. These preliminary findings for year one of four of SEADAP have impacted teachers and their students and addressed the limitations of current drug prevention programs.

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Appendix A
SEADAP
Professional Development Exit Questionnaire

Name (optional):______________________________

To what degree do you agree with the items below? (5 Strongly Agree – 1 Strongly Disagree)	Rate the item using scale below					
The professional development…	5 Strongly Agree	4 Agree	3 Neutral	2 Disagree	1 Strongly Disagree	0 Not Applicable
1. increased my awareness about the prevalence of drug use.	⑤	④	③	②	①	⓪
2. increased my knowledge of the hazards of using addictive substances.	⑤	④	③	②	①	⓪
3. increased my knowledge about the science of drug addiction.	⑤	④	③	②	①	⓪
4. increased my skills as they relate to using planarians in basic science research.	⑤	④	③	②	①	⓪
5. increased my awareness of science-related careers (particularly biomedical careers).	⑤	④	③	②	①	⓪
6. was of high quality.	⑤	④	③	②	①	⓪
7. was relevant to my needs.	⑤	④	③	②	①	⓪
8. provided important resources for me.	⑤	④	③	②	①	⓪
9. met my expectations.	⑤	④	③	②	①	⓪

What was the most useful part of this staff development? Why?

What was the least useful part of this staff development? Why

Appendix B
Focus Group Session (FGS) Before Implementation

Do you have any questions about the purpose of the focus group or your consent/willingness to participate today?

[*Interviewer will record and answer all questions at this time. Interviewer will give interviewees a copy of the application consent form they previously signed]*

Overall Teacher Reactions to SEADAP:

- In a short phrase or single word, please explain how you would describe the SEADAP professional development sessions?
- How did this professional development experience compare to professional development you have received in the past? What changes would you suggest to improve the experience for future cohorts of SEADAP teachers?

Teacher Learning Outcomes:

Provide examples of how the SEADAP did, or did not:

- Increase your awareness about the prevalence of drug use.
- Increase your knowledge of the hazards of using addictive substances.
- Increase your knowledge about the science of drug addiction.
- Increase your skills as they relate to using planarians in basic science research.

Teacher Preparation for Implementation:

- In what ways, if any, did the professional development sessions prepare you with the appropriate content knowledge to successfully develop relevant inquiry-based SEADAP lesson plans for your classes?
- In what ways, if any, did the professional development sessions prepare you with the appropriate procedural knowledge to successfully use planarians in your classroom? (*Probe:* How many had used planarians in the past? In what ways? How will you use them differently for your SEADAP lesson(s)?)
- What additional training/support/resources, if any, do you anticipate you will need in order to use planarians in your classroom?

Appendix C
Science Education Against Drug Abuse Partnership (SEADAP)
NC Pretest and Posttest

Instructions: Please respond to the following items. For each item, please select one answer unless otherwise specified.

1. Which of the following substances is considered a drug?

☐ alcohol ☐ caffeine ☐ sucrose ☐ all of the above

2. Which of the following is categorised as a depressant?

☐ energy drink ☐ beer ☐ coffee ☐ all of the above

3. Which of the following is an effect of drug addiction?

☐ anxiety ☐ memory loss ☐ decreased motor skills ☐ all of the above

4. When someone uses drugs repeatedly, their brain ________.

☐ becomes smaller than before ☐ becomes larger than before ☐ becomes trained to crave the drug ☐ all of the above

5. After a prolonged period of drug abuse, the brain ________.

☐ needs less drug to get the same effect ☐ needs more drug to get the same effect ☐ experiences increasing amounts of dopamine ☐ none of the above

6. Repeated drug abuse can change the brain and "hijack" the brain's reward system. This means:

☐ large amounts of the chemical dopamine flood your system, creating the "high" ☐ things that normally make you happy aren't fun anymore ☐ drug cravings become nearly impossible to ignore ☐ all of the above

7. Drugs of abuse create intense feelings because they ____________.

☐ slow down the nervous system ☐ shut down brain receptors ☐ cause a rise in dopamine in the limbic system ☐ none of the above

8. Alcohol can affect the cerebellum, which is the brain area involved in ____________.

☐ controlling basic functions such as heart rate and breathing ☐ muscular movement, balance, and posture ☐ memory, emotions, appetite and thirst ☐ all of the above

9. Humans are in their early to mid-twenties before their brain is fully matured. This is why people get concerned when teens use drugs, because chemicals can affect the developing brain. The last part of the brain to mature is the:

☐ limbic system ☐ nervous system ☐ prefrontal cortex ☐ none of the above

10. Which is an example of what a biomedical researcher does?

☐ studies the effects of various chemicals on the human body ☐ investigates new technologies or disease treatment methods ☐ conducts research on animals and/or on human subjects ☐ all of the above

11. Why are rats and mice often associated with medical research?

☐ they like similar foods and drinks as humans ☐ they have similar sleeping habits as humans ☐ they share 99% of their genes with humans ☐ all of the above

12. Planarians are ideal for biomedical research because they _______________.

☐ are mammals

☐ are similar to humans in terms of their eating and sleeping patterns

☐ display addiction-like behaviors to many drugs abused by humans

☐ all of the above

13. Which of the following would <u>not</u> be a career related to biomedical research?

☐ meteorologist

☐ pharmacologist

☐ physiologist

☐ forensic scientist

Appendix D

FGS Response Set

Teacher responses acknowledged how the content is applicable to teenage students and provides information on *relevant* effects of the hazards of using addictive substances on the human brain. For example a teacher said, "I think … that during that age while you hit puberty… that if they start trying it at that point that sets them up to be sort of at risk... So, I think, as far as who I teach, that was applicable." This teacher realized a need for SEADAP which increased her awareness about the dangers of teenage students becoming addicted to drugs. And another teacher said the program provided more information than current drug prevention programs. She said, "One of the failings that I remember from D.A.R.E. is that it told you all about the like short-term effects of drugs, but it didn't explain that it actually changed the way your brain functioned…" The DARE provided limited knowledge and teachers found the SEADAP pertinent to student instruction about drug addiction.

According to the teachers, they were given detailed and clear explanations about the science of drug addiction. Teachers became more *knowledgeable* about how the brain works. A teacher reported, "I noticed that my kids behave better if I can give them the reasons that their brain is making them behave the way they are, you know. It works better than saying, "Don't do that, it's bad…" The teachers believed that they became empowered to communicate better with their students about drug addiction and abuse.

Although teachers perceived themselves to be knowledgeable about SEADAP related content, they said their *comfort* level to implement SEADAP related labs was limited. They indicated that they needed more hands-on experience with using planarians. For instance a teacher said "We need to play with them (planarians) …so that we can actually see it ourselves…I'll feel more comfortable with really doing this with my students." Teachers stated that in order to be more comfortable with implementing hands on SEADAP investigations that they needed lab procedures to follow. One teacher commented, "I need to know how much water do I put into the petri dish, and then how much solution, I need exact measurements ..." These teachers needed more detailed instruction before they felt comfortable with the implementation of SEADAP experiments in the classroom.

Teachers acknowledged that SEADAP would allow students to learn more about designing experiments using the *scientific process*. As noted by a teacher "Even though we're (teachers) going to develop lessons… you have different concentrations, you make the kids think they're coming up with that. You know what I'm saying? So the kids are, they're designing it. They feel like they are designing the experiment even though we're guiding them in this way… you (student) do a science fair project, … you (student) can take what you learned how to do here and create your own experiments with them" . Even though SEADAP is focused particularly on issues related to drug abuse and addiction, teachers realized student learning extended to knowledge about the scientific process.

The teachers said that they thought their students would also be *engaged* during the implementation of SEADAP investigations. A teacher said, "Especially the doing. One thing that I've noticed, labs, of course, are absolutely more engaging but when you bring a live creature (planarian) into the room, the engagement (will be) huge. Another teacher said that students become more focused when provided the opportunity to do hands on lessons; "I was doing a density lab with water and things like that. They were all over the place, really chatty…when those planarians come out on the table, they will focus on nothing else but what is going on right in front of them". Teachers realized that incorporating SEADAP lessons into instruction would increase student engagement.

Teachers did not anticipate having any *issues with implementation* of SEADAP lessons. A teacher thought that her administrators would be very supportive. She said, "We were presented with - what was it - eight or nine lessons. We were asked to do two. When I asked my administrator if I could have five class periods to do these different things, he was fully supportive." She did not anticipate any problems and believed that she would have the flexibility to implement SEADAP lessons.

Although NC Teachers really believed teaching SEADAP lessons would be well received by students, teachers and administrators, they seemed unclear about the *program focus*. A Teacher said "Kids are going to be excited about using planarians, but what do you want them to learn from the program? It appeared teachers believed SEADAP is a good project but unsure about the program goals.

Appendix E

Observation of SEADAP Lesson Use in the Classroom Protocol

Observer/Interviewer:	School Name:	
Observation date	Time Start	End
Teacher	Grade Levels of students:	
Teacher Gender: Male___ Female___	Course Title:	
Teacher Ethnicity:		
Students: Number of Males _____ Number of Females _____		
Classroom Race/Ethnicity: *(provide estimates so total % equals 100%)* % Asian _____ % African American/Black_____ % Hispanic/Latino ______ % White _____ % Other _____		

Classroom Environment

1) Please give a brief description of the classroom setting in which the lesson took place (space, seating arrangements, etc.). Use diagrams if appropriate.

2) Was the lesson taught in a:

- ☐ Traditional classroom setting (e.g., desks only, no access to running water in room)
- ☐ Science lab setting (i.e., classroom with running water, lab tables, etc.)
- ☐ Other explain: ____

Lesson Topic(s) and Goal(s)

3) Were you provided a copy of the **lesson plan** during or prior to the observation?

- ☐ No
- ☐ Yes, I had access to the lesson plan explaining the entire unit
- ☐ Yes, but I only had access to a partial lesson plan (e.g., explaining only the lab experiment, or only that class period—and not an overarching lesson plan)
- ☐ Other: ____

4) When in the overall SEADAP **lesson sequence** did this class/lab takes place?

- ☐ Toward the beginning of the SEADAP unit
- ☐ In the middle of the overall SEADAP unit
- ☐ Toward the end of the overall SEADAP unit
- ☐ Did not have enough information to determine
- ☐ Other: ____

5) According to the teacher (written or spoken), what were the **lesson goal(s)?** In other words, the purpose of the lesson was…

6) Which **topic(s)** were addressed during the SEADAP lesson observed? *(check all that apply)*

☐	prevalence of drug abuse in society	☐	hazards of using addictive substances	☐	science of drug addiction
☐	use and importance of the scientific process and experimental design	☐	use, care, and importance of animals in basic research	☐	role and importance of biomedical research
☐	importance of and opportunities available in terms of STEM careers	☐	none of the above	☐	Other:

7) What types of curriculum materials were used *(include any textbook, lab materials, or resources used)*?