Methodologies and Results of a Two -Year Project Promoting Integrated Pest Management and Chemical Use Reduction to Promote Science and Improve Health

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***Abstract*—** *Researchers from three universities worked with multiple 6-12 grade teachers from 2013 to 2015to engage them and their students in developing science projects and learning applied science concepts. These projects focused on integrated pest management (IPM) and chemical use reduction (CUR) in the home. The objectives of the program consisted of increasing awareness about IPM and CUR, and promoted inquiry based leaning, while employing a new model of engagement in the classroom (i.e., liberating structures). Arm 1 of the program first engaged a large group of teachers (i.e., 75) in two-day trainings. A selected group of trained teachers then joined with researchers and trained graduate students to actively engage their 6-12 grade students in the classroom. Arm 2 involved the development and implementation of a more focused 10-day IPM and CUR curriculum to be used in the classroom, along with a 4-hr online training for teachers designed to facilitate its implementation. In an effort to create a balanced and comprehensive experience for those who participated, researchers from graduate science and communication, and K-12 STEM programs composed the project team. This article reports on the methodologies employed, experiences and overall metrics of the program. Recommendations are given to improve the process and the results based on participant experiences. Useful information is provided for those in the field planning to better engage the community and in particular 6-12 grade students in science and health education. Curriculum and other materials (i.e., brochures) are available at no cost online in English and Spanish.*

Keywords*— *Liberating Structures (LS), Science Education, K-12 Science, Integrated Pest management (IPM), Chemical Use Reduction (CUR), Community Outreach.

I. INTRODUCTION AND BACKGROUND

The community plays a vital role in the health and condition of the environment and consequently, the health of mankind. Finding innovative techniques that engage the public in key environmental and health issues will increase community ownership which will lead to greater solutions. This program addressed two important environmental and health related topics of integrated pesticide management (IPM) practices and chemical use reduction (CUR) in the homes with the goal of promoting better indoor air quality, healthier homes and healthier people, using a new model to successfully engage and create shared meaning with participants (i.e., Liberating Structures (LS)). LS consist of variable structures that encourage input from all parties that want to engage on an idea, a problem, or a solution (MacCandless and Lipmanowicz, 2012). LS structures, sometimes altered specifically for the project, encouraged open communication in the project's education and outreach objectives with schools, teachers, graduate students and 6-12 grade students and their parents.

The Environmental Protection Agency (EPA) funded this project as a model for other environmental education opportunities and projects. As the main federal agency with oversight on the environment, the EPA's goal is not only to set standards for the release and use of chemicals in the environment, but also assisting people in "making informed decisions and taking responsible actions towards the environment'" they live in (EPA, 2015). The EPA's goals addressed educational priorities of "*Human Health and the Environment*" and "*Career Development*" in addition to EPA's environmental priorities of "*Protecting Air Quality*" and "*Assuring the Safety of Chemicals and Preventing Pollution*" (EPA, 2015). The training and engagement of teachers and young students on environmental issues that directly affect human health addressed the educational priorities of "Human Health and the Environment and Career Development". The shared messages and education on IPM and CUR in the home provided information to current and future generations, and satisfied the environmental priorities of "Protecting Air Quality" and "Assuring the Safety of Chemicals and Preventing Pollution".

Indoor air quality has been recognized over the last few decades by scientists as an important factor to human health. Indoor air quality contributes to increased adverse health outcomes based on the increased time spent indoors by populations (especially the very young and very old) and the trapping of pollutants indoors due to increased energy efficiency from better sealed homes (Gale 2009).Unmanaged sources of biological, chemical and physical contaminants pose a threat to indoor air quality and human health. Pests in the home can result in a number of health problems (e.g., asthma), (Kanchongkittiphon, 2014) damage to the home property and emotional trauma. Healthy indoor air quality requires all households to maintain a pest-free home(Huss et al., 2011; Ciaccio et al.,2012; Wada et al., 2011; Tovey and Ferro, 2012; and Torjusen et al., 2013; Gao, 2012, Page, 2012). Treatment with pesticides can be one solution, however, excessive and inappropriate uses of pesticides are suspected in a multitude of health problems (e.g., cancer, neurodevelopment disease) (Eskenazi et al., 1999). Integrated pest management (IPM) practices entail a comprehensive and holistic approach to pest control by promoting non-toxic management of pests through activities such as maintaining a clean, dry and sealed home, and using pesticides only when other methods fail (Sandel et al., 2010).

Individuals use an immense and varied array of chemical products for the home for uses such as cleaning, home maintenance activities, and for personal care(EPA, 2010; Moran et al., 2012). These products include pesticides, cleaning products, candles, and building materials, and cosmetics (Masuck et al, 2011; Derudi et al., 2012; Batterman et al., 2012; Guerrero 2012; Golden et al., 2011, and Dodson et al., 2012). Over and improper usage can have adverse effects on health (i.e., asthmatic triggers, poisonings deaths) (Anderson et al., 2012; Moran et al., 2012). Chemical use reduction and related strategies (i. e, safer products, and ventilation) can be imparted to the general public to promote individual and community health.

Promoting science education in all K-12 schools and classrooms is imperative, and increased benefits can be accomplished by Universities working with K-12 programs to promote cooperative learning and expand the abilities and accomplishments of young students (Komoroske et al., 2015; Shroyer et al., 2007)). Although this project promoted environmental and health applied science areas, the outreach and educational strategies used by various programs in the past vary in the topic areas, approach, objectives and outcome measures. All, projects and partnerships however have some desire to expand the learning and growth opportunities for young children (e.g., Shein and Tsai, 2015; Hardre et al., 2016; Moskal et al., 2007; Salas-Morera et al., 2013). Taiwanese scientists, for example, initiated a High Scope Program in 2006 with 28 schools to facilitate partnership between high school teachers and higher education scientists and discovered that the program had a significant influence on a student's "situational and individual interest" in addition to increasing a "teacher's knowledge content" (Shein and Tsai, 2015). The British Colombia Year of Science program, as another example, facilitated engagement in earth sciences with a collaborative approach between schools, universities, private sector, and communities, and found that they increased student interest in the sciences (Van der Flier-Keller, 2011). Likewise, in a year-long program, Oklahoma University researchers mentored K-12 math and science teachers in engineering concepts resulting in later increased use of "inquiry-based pedagogical strategies" in the classroom of their young children (Hardre et al., 2013).

II. MATERIALS AND METHODS

Partners on this grant included: 1) the University of Arkansas for Medical Sciences, College of Public Health, Department of Environmental and Occupational Health with professors experienced in pesticide and other chemical exposures, air quality and outreach and education, 2) the University of Arkansas at Little Rock's, Department of Speech Communication with researchers experienced in communication and leadership, 3) University of Arkansas at Little Rock's (UALR) STEM center with a science liaison for the Pulaski County School Districts, and 4) University of Arkansas Pine Bluff's (UAPB) Math and Science Center with a science liaison for the Jefferson County School Districts. The University affiliated STEM and Science centers promote science and math applications in schools to enhance the quality of education for teachers and students, and are two out of eleven such centers in the State of Arkansas. Graduate students from the three Universities, in addition to the Clinton School of Public Service (CSPS), were involved in the classroom engagement to enhance their learning experiences and our project objectives. Increasing environmental and health knowledge on IPM and CUR among teachers and students in K-12 programs and stimulating inquiry based learning, through practice with science projects on these topics, were objectives of the program. By using a new model for engagement in the classroom (i.e., use of various liberating structures), the project aimed to create excitement and more lasting awareness on these topics as a third objective. Another long term objective, not entirely measurable in the program, was to prompt actions in the home by teachers, students and parents that would have a positive impact on health.

The project group recruited teachers and schools predominantly from demographic and socioeconomically different counties of Arkansas through their affiliated STEM and Science Centers at UALR (located in the Pulaski County) and UAPB (located in Jefferson County). African-Americans represent 30% and 50% of the population in Pulaski and Jefferson Counties, respectively (U.S Census Bureau). The actual demographics for the individual schools or students that ultimately participated may have been different. In addition, other counties that wanted to participate in the program were not excluded.Approval for the project was obtained through the University of Arkansas for Medical Sciences Institutional Review Board (IRB) in two phases. Teacher trainings received expedited approval (IRB#202087) while work in the K-12 schools on science projects received exempt approval (IRB #202301). Grant funding through the Environmental Protection Agency (#NE-00F65601-0) paid for science supplies for the schools and stipends for the K-12 teachers and the graduate students that participated in project. The educational and outreach design between partners and target groups contained two Arms (i.e., Arm 1 and Arm 2) to achieve project objectives.

2.1 Arm 1 Activities

2.1.1 Teacher training

Partners organized teacher trainings in the summer 2013 and summer 2014 to cover IPM, CUR, other healthy homes topics, the scientific method, and the integration of those topic areas into a middle school and high-school curriculum. The project group held these trainings for 8-hours over two days in Jefferson and Pulaski counties each year. Teachers earned 6 accredited hours of professional training through the Arkansas Department of Education for their attendance and also received materials (i.e. project brochures and a ‘display kit’ of items related to IPM and CUR) to share with their classrooms. The trainings not only involved lectures by the project team, but importantly included multiple engaging activities and discussion using liberating structures. A previous publication covers the format of the trainings and results of pre and post-surveys delivered to teachers during the 2013 trainings (Ferguson et al., 2015).

2.1.2 Training Graduate Students

Graduate students participated in the extended program of Arm 1 by working with chosen teachers and their students directly in the classroom. The students assisted in designing and preparing science projects. Graduate students first received training from the project research team by attending a 4-hr training covering the environmental and health issues of IPM and CUR. These graduate students also received guidance for working with the teachers and young students in the classroom, in an appropriate manner and in a fashion to promote engagement and excitement. The project group demonstrated liberating structures with graduate students in order to encourage their use with K-12 students. Over the course of 4-6 months graduate students gave a minimum of 50 hours of interaction time in the classroom, and reported routinely to the project research team on progress with science projects, supply needs, and any scientific support (e.g., K-12 science project reviews, research literature, access to equipment and facilities at any of the universities).

2.1.3 Working with K-12 students in the classroomin the extended program

A select few of the trained teachers participated in the extended program of Arm 1 with one or more of their K-12 classrooms. The project group chose teachers based on interest, by order of sign-up, ability to get letter of approval from school principal, and the need of the program to create balance across the counties. The classroom activities with K-12 students started with introductory presentations and interactions on environmental topics and the scientific method given by one or more of the project team members. The project group introduced the assigned graduate students to the K-12 students and their teacher during the introductory presentations. Later presentations and discussions with the K-12 students followed based on team teaching by the teacher, project team members or graduate student. The graduate students then began the process with the teacher to assist the students in coming up with scientific ideas, designing projects around these ideas, implementing the projects, and preparing papers and/or boards for science fair competitions held in classrooms, schools or at Universities (i.e., science or regional fairs). Project teams guided teachers and graduate students through a timely progression of activities, and also participated in judging classroom and school fairs and recommending and facilitating particular science projects for entry to University fairs (i.e., a more competitive environment).

2.1.4 Parent workshops

Following teacher trainings and through the course of work in the classroom with K-12 students, the project team invited parents to attend a 1.5-hour parent workshop during each of two-years in each in Pulaski and Jefferson County (note this resulted in 4 parent workshops). The project group arranged these parent meetings with the teachers and their K-12 students. The objective of a parent meeting was to encourage parents and students to work together to improve their home environment by following IPM and CUR principles and to produce quality science projects. The project team also introduced parents to resources (i.e., local organizations, healthy home websites) for improving the home environment, and displayed items to keep the home healthy and safe (e.g., carbon monoxide monitor,pesticide baits, filters for air conditioning units).

2.1.5 Website Development

In order to reach a larger audience and create a platform for further communication and learning, the project group designed a user friendly website (affiliated with the UAMS-College of Public Health) that covers all the concepts related to IPM and CUR in the homes, in addition to valuable liberating structures useful for teaching environmental and science at the K-12 level. The project group made links to resources available for teachers, parents and students on the website (found at http://publichealth.uams.edu/pmcr/)

2.2 Arm Activities

2.2.1 10-Day Curriculum Implementation in Schools

Based on the experiences from Arm 1, the project group developed a formal 10-day curriculum on IPM and CUR and implemented the curriculum in the classrooms of four K-12 teachers (one middle school and 3 high-schools). These teachers had the assistance of project team members who gave select presentations, and graduate students who gave a minimum of 30 hours assistance over a two-week period. The curriculum was designed for the middle-school level (6th-8th grades) where activities could and was integrated to increase the scientific level and application for more advanced high-school students.

2.2.2 Curriculum Improvements

Using recommendation from teachers and graduate students based on their post surveys and shared experience, the 10-day curriculum was improved and made available online (http://publichealth.uams.edu/pmcr/10-day-k-12-curriculum/) in Spanish and English and contains a mix of lectures, classroom debates, and hands on activities. The hands on activities are centered on using specific liberating structures to get more active participation and create a more memorable experience for the student and teachers. The 25-page curriculum is associated with 6 Microsoft PowerPoint or Prezi format (www.prezi.com) presentations for use in the classroom.

2.2.3 4-hr Online Training

To facilitate implementation of the 10-day curriculum, a free 4-hr training is available to teachers through Blackboard (available at:

https://www.coursesites.com/webapps/Bb-sites-course-creation-BBLEARN/courseHomepage.htmlx?course_id=_384372_1). The 4-hr training is self-guided with voice-over lectures and links back to the project website and 10-day curriculum.

III. PROJECT EVALUATION

An evaluation component was integrated into project activities (i.e., Arm 1 and Arm 2) to assess the impact and outcome of the model and its application to specific targets groups, and included a variety of pre and post surveys. Activities for Arm 1 of the project was designed over a two year period of repeated activities, allowing for improvements to be made to activities in the second year based on assessments of the surveys, and recommendations from the participants and experiences of the project team from year 1. Activities from Arm 1 then allowed for the development of the 10-day curriculum on IPM and CUR for Arm 2.Implementation of the curriculum in schools allowed for the team to make recommended improvements.

IV. RESULTS AND DISCUSSION

4.1 Objective 1: Increasing awareness on IPM and CUR, using inquiry based learning

Table 1 shows the groups and participation rates over Arm 1 and Arm 2 of the project. For Arm 1, 75 middle and high school teachers (from 55 different schools) participated over the two years in the teacher trainings, where 15 teachers of those from 13 different schools were chosen to work with their students and given the assistance of graduate students in the classroom on science projects in the extended program. The 75 teachers that participated were predominantly science and math teachers (only one teacher indicated teaching English only) based on our targeted efforts and the topic areas covered (i.e., IPM and CUR). The program directly reached over 1000 students in the classroom, predominantly in two school districts. Close to two-thirds of those students participated in the development of science projects and one third completed projects successfully and entered in class or external fairs held at local Universities. In Arm 2 of the program, 4 teachers participated from 3 schools with 325 of their students, getting more intimate and direct teachings on IPM and CUR, where hands on activities included pest identification and a lab to make homemade laundry detergent. There were a total of 17 graduate students that participated in Arm 1 and Arm 2 of the program. Table 2 shows the types and numbers of pre and post-surveys collected on the project to evaluate project objectives and improve activities in Arm 1 and Arm 2, where not all participants completed pre and post-surveys across the various stages of the project. Below are general recommendations from those surveys and from our experiences in the field.

4.1.1 Arm 1 Experiences

In Arm 1 for the teacher trainings, pre and post-surveys from the first set of teacher trainings in 2013 were used to enhance our training methods in the second year, including more hands on activities with liberating structures to facilitate the teachings on IPM and CUR. From the first trainings, it was observed that science teachers needed additional instructions covering the scientific method. Teacher trainings in the second year therefore included a competition with teacher teams to demonstrate the presentation format for a scientific board and accordingly, elements of a science project. Recruitment was conducted through the STEM and Science Centers using word of mouth and their teacher lists of emails. To increase participation in teacher trainings, we recommend contacting school district levels administrators and school principals to have them encourage teachers to take these trainings for professional development credits. Based on our experience and comments from the teacher it is recommend that trainings be a day long (if trainings can be made concise without loss in scientific content) to also increase enrollment. A fully functioning website and experience with training in year one allowed year two to progress more smoothly and allowed us to improve the training format and experience for the teachers. There was a desire by some high schools and more advanced teachers to have the project team devote more time on scientific content (i.e., chemistry concepts related to chemicals used in the home). The project team was able to add more advanced links to the website for the second year and at least direct those teachers to the site. Future projects should consider developing at least a partial website with some content before any project activities ensue.

Based on the post surveys, the 15 teachers in the extended program of Arm 1 felt it was a new and fresh program, and brought excitement to the class. Only 1 of 15 had entered external science fairs with K-12 students previously, and over half had never completed any science projects with students. They appreciated the immense help and interaction with the universities and in particular with the graduate students in the classroom. They indicated that even more assistance would have been valued given the many student projects needing assistance. There was a great appreciation for project supplies, especially to assist the children in need. In both years there was the occasional mis-match in personalities between a graduate student and a teacher due to conflict in approach (e.g., which student needed the most help) and timeliness with achieving goals in project phases. Graduate students needed to understand competing interest in a classroom for the teachers and the demand on their schedule in meeting curriculum requirements of the school and district. There were different levels in commitment with the teachers and different levels of passion for the subjects, the science fair process, and for their K-12 students. Additional ground rules (e.g., hard deadlines for aspects of science project development) could have been established by the project team on expectations from teachers, graduate students, and even project team members.

The school environment made a huge impact oftentimes on the success of the program in the schools. The greater support from principal and administrator increased the success and comfort level of the teacher and students in accomplishing goals and even being successful at regional science fairs. The less disadvantaged schools (i.e., schools located in wealthier areas of Arkansas) tended to demonstrate greater support from administrators and also from parents. Nevertheless, this program was able to achieve great success across schools, despite some challenges, primarily because of the desire of committed teachers to give their students greater learning opportunities and expand their experiences. Many of the teachers on their post-surveys commented that they made changes in their own home to reduce exposure to pesticides and harsh chemicals. In the first year, teachers suggested more emails and reminders on science fair requirements and more interaction with STEM centers. STEM Center scientists made more visits and sent additional emails to inform schools of the University science fairs and other training opportunities in the second year. A full functioning website in the second year increased the level of interaction and the functionality of the program.

For the graduate students in Arm 1, the project team was impressed by the commitment level of the graduate students from all the schools, where most graduate students gave additional time in the classroom to young K-12 students. About 13 of the 15 students that participated directly in the classroom were highly motivated and 2 needed the occasional reminder to meet with teacher and students to progress through science projects. Some graduate students wanted more interaction and more opportunity to better shape the science projects, given class times were short. All of the graduate students indicated increased understanding of IPM and CUR and commented on making positive changes in their own homes (i.e. safer chemical projects, practicing increased cleanliness) based on their post-surveys.

For K-12, of the 593 students that completed pre-surveys before becoming involved in science fairs in the extended program, approximately 25 % recalled ever having heard about the topics of CUR, IPM or liberating structures. Their level of familiarity with the topics could not be confirmed. Occasionally, on prodding this knowledge, the young students did not demonstrate meaningful understanding of concepts. Based on the pre-surveys the grant reached out to mostly 12 and 13 years across the two years (63%). However, ages from 10 to 17 participated. Approximately 39% indicated that science projects were difficult, but the majority (65%) remembered completing a science project at least once in their lifetime. Although this question was not on the survey, teachers indicated that the majority of students had never competed in a classroom or outside science fair. This project allowed these children to think competitively about their science projects and work with Universities and graduate students to develop stronger ideas and meaningful projects on IPM, CUR, other healthy home concepts, and a range of other science area topics.

Although some of the students that competed in the science fairs held in schools, classrooms, or at Universities had successful outcomes (i.e., first, second, or third place wins, in some cases honorable mention), the project objective was to expose them to IPM and CUR topics and encourage critical thinking of these topics through science projects. The project team often reminded teachers and K-12 student of the great benefits in competing in science fairs (i.e., exposure to the process, interacting with other schools). Many children and teachers new to science fair competitions were impressed by the level of competition and quality of student projects from competitive schools in the region. It was not practical for all students to find a meaningful topic of research on IPM and CUR and the project team encouraged and supported all science and health topics. An unintended objective of the project became “help students successfully learn the scientific method and apply it to any area of interest”. The project team stressed that young students specifically address potential application of their science ideas to benefit mankind. We recommend that future projects try to engage a larger community of scientists (i.e., building a network of professors and graduate students) willing to review project ideas and assists students, thereby expanding the possibilities of engagement (Komoroske et al., 2015).

The project was able to engage only 212 parents through 4 workshops, though more parents were engaged with their children through their science projects. There were varying levels of engagement from parents on their child’s school projects as observed by teachers and the project team, where stronger and more successful science projects often demonstrated the commitment of parents. Future projects should find more ingenious formats to engage parents in their student’s work.

4.1.2 Arm 2 Experiences

The teachers that participated in the 10-day curriculum implementation were highly motivated teachers from Arm 1. The curriculum was initially drafted by a UAMS graduate student working on her graduate Master in Public Health Culminating project who had experience as a teacher. One project team member supported one of the teachers, while three graduate students worked with the other teachers. Pre and post-surveys completed by the K-12 students that participated indicated tremendous learning growth from the students given more intimate contact with the IPM and CUR topics to increase the memory retention and exploration of ideas. Stronger schools (based on district ratings) demonstrated stronger pre-knowledge with basic science concepts embedded in the curriculum, showing the need for increased STEM education and emphasis across all schools. A later publication based on implementation this curriculum is planned by the project team. However, post-surveys from the teachers and graduate student were extremely important in helping the team to make improvements to the online curriculum and to the development of the 4-hr online training for teachers. All teachers and graduate students talked about the K-12 students enjoying the lab and interaction activities within the curriculum. Teacher also suggested opportunities for more chemical research for the older K-12 students to potentially distinguish harmful versus safer chemical products for home and personal use. Graduate students also suggested ways to have parents become a part of the learning experiences for the younger students. These suggestions lead to the addition of suggested parent activities, group activities, and links to chemistry research sites in the curriculum.

TABLE 1
METRICS ON GROUPS REACHED

Groups	Reached	Project Experiences and Comments
Arm 1:Teachers attending two-day training, Year 1 and Year 2	75 across multiple schools, cities and counties	Harder to recruit to the two day training than anticipated despite stipend and professional hours offered. A one-day course might be more practical.
Arm 1:Teachers participating in the extended program, Year 1 and Year 2	15 from 13 different schools	All teachers had to receive approval through their School Principals to participate in this extended program
Arm 1: K-12 Students In Year 1 and Year 1 in extended program	-1066 exposed IPM and CUR concepts -2/3 of that number participated in science projects -1/3 completed and entered in class or regional/local fairs	The project team and graduate students worked with multiple classes for each teacher, requiring project development, completion and entrance into science fairs.
Arm 1;Parents reached at 4 workshops in extended program	212 (4 schools)	Other parents participated through their interaction with their children's participation in science projects, science fairs, and in the 10-Day curriculum implementation
Arm 1: Graduate students involved, Year 1 and Year 2 in extended program	17	One graduate student participated from Year 1 to Year 2. Two other graduate students participated through brochure preparation and assistance on curriculum development
Arm 2: Graduate students involved in 10-day curriculum implementation	3	These students were pulled from original graduate students above to participate in a more extensive program.
Arm 2: Teachers participating in 10-Day intense curriculum implementation	4 from 3 different schools	These very active/enthusiastic teachers previously participated in Arm 1 and enhanced this project greatly through the implementation of the 10-day curriculum. One project team member worked with one of these teachers.
Arm 2: K-12 students participating in 10-day curriculum	325 (183 completed pre and/or post surveys)	This 10-day curriculum implementation and the teachers and number of student that participated greatly enhanced the goals of the project. These students also participated in Arm 1 and were exposure to a less intense curriculum on IPM and CUR
Arm 1 and Arm 2: Website visits (Date: 8/1/2015 through 09/01/2015)	3699 hits (2654 are unique views)	Potentially other teachers and student in Arkansas and elsewhere were impacted by this project.

TABLE 2
EVALUATION INSTRUMENTS: PRE AND POST-SURVEYS

Groups	Delivery Time	Content	Number collected
Arm 1 a)Teachers: Pre surveys, Year 1 and Year 2	Before 8-hr teacher training	Pre-knowledge on project topics and demographics,	72
Arm 1: b)Teachers: Post surveys, Year 1 and Year 2	After 8-hr teacher Training	Post-knowledge on project topics, demographics and training satisfaction	69
Arm 1: c) Teachers in extended Program Post Survey, Year 1 and Year 2	After completion of science projects and science fairs	Satisfaction and thoughts on implementation of extended program and working on science projects with graduate student assistance	15
Arm 1: d) Graduate school students: Post Surveys, Year 1 and Year 2	Close of project and completion of science projects	Satisfaction and thoughts on implementation of extended program and working on science projects with K-12 schools	14
Arm 1: e) K-12 students: pre surveys , Year 1 and Year 2	Before science project implementation over the two years	Pre-knowledge on project topics, experience with science projects, demographics.	593
Arm 2: f) K-12 school students Pre-survey, Year 2 only	Before implementation of 10-day curriculum	Pre-knowledge on curriculum topics, demographics	183
Arm 2: g) K-12-students Post Survey,	After implementation of 10-day Curriculum	Post knowledge and retention of curriculum topics	121
Arm 2: h) Teachers-Post Survey:	After implementation of 10-Day Curriculum	Experience with implementing 10-Day curriculum, feelings on improving curriculum	4
Arm 2 a) Graduate Student Post Survey:	After implementation of 10-day Curriculum	Experience with implementing curriculum, feelings on improving curriculum	3
Note: Parental surveys were not delivered due to short timing of parent workshops			

4.2 Objective 2: New Model of Engagement: Use of Liberating Structures (LS)

One objective of the project was to introduce a new model for engagement (i.e., liberating structures) in the classroom. Partners used specific liberating structures to engage and achieve action towards understanding environmental stewardship and personal health. Table 3 contains a list of various liberating structures and their usage to engage the various groups in Arm 1 and Arm 2 of the project activities. These liberating structures have specific formats of engagements with a group of individuals that were adapted for use on the project. This is the first application of liberating structures to K-12 learning and education in the environmental sciences that this team is aware of through literature searches.

TABLE 3
VARIETY IN THE USE OF LIBERATING STRUCTURES IN THE PROGRAM

Liberating structures	As described by authors who first developed the 33 liberating structures.	Used where?	Project application
Impromptu Networking and Shift and Share	'Rapidly share challenges, build new connections'	Teacher trainings. Parent meetings	Teachers introduced themselves and their science expertise to the group. Parents introduced themselves at parent meetings. "Conversation café" was another liberating structures used to encourage teachers to mill around the room to get to know others.
Shift and Share	'Spread good ideas and make informal connections with innovators'	Teacher training	Used occasionally when there was an expert teacher on a topic and the teachers wanted to share ideas among themselves
9 Why	'Make the purpose of you work together clear'	Teacher trainings	This structure was used to show the teacher the importance of reducing exposures in the home environment. It was not always the "9 whys" (i.e., could be '8 why' on a subject).
TRIZ	'Stop counter-productive activities and behaviors to make space for innovation'	Teacher trainings	This structure was used to illicit from the teachers the difficulties in teaching science in the classroom and in motivating the students on science projects. In this manner we were able to better understand challenges. Other teachers were able to offer solutions. We were able to suggest other liberating structures useful for resolving problems and conflicts. We also used this structure for class debates within the 10-day curriculum implementation. We toyed with another liberating structure called "wicked questions" in a similar format.
1-2-4-All	'Engage everyone simultaneously in generating questions/ideas/ Suggestions'	Teacher training, graduate trainings and heavily used in the classroom	By far this structure was the most commonly used liberating structure, because it was simple and got everyone participating in the current activity of learning and sharing. Every child or every teacher had to ponder over a topic, then share with one person and then with four before sharing with an entire group or an entire classroom. There were meaningful thoughts shared from everyone using these structures. This was heavily used during the curriculum implementation when groups of K-12 students had to come up with a brochure on a healthy homes topic
Heard, Seen, Respected	'Practice deeper listening and empathy with colleagues'	Teacher trainings and during project team meetings	Teachers thought this structure was adaptable for communicating with administrators on the needs in the classroom and in working with students and parents in order to meet curriculum expectations. This structure was also used during project meetings to make sure each STEM center representative and project team member was heard.
What I need from You	'Surface essential needs across functions'	Teachers in the classroom	To develop a sense of timeliness on project deadlines and expectations, this structure was used to move young students along in their projects. Project team members suggested this structure for teachers to use with parents when discussing learning and participation expectations for students and parents.
User Fish Bowl Experience	'Share knowledge-gained from experience with a larger community'	Teacher trainings	Teacher utilized this to get students to talk about their individual projects.Project team also used this structure in a teacher training to get two experts to share their IPM experience and to field questions from the teachers.
Social network webbing	'Map informal connections and decide how to strengthen the network to achieve a purpose'	Development of website and use of teacher List serve and emails for networking	The website was a valuable tool in disseminating project materials and sharing links.
15% Solution	'Discover and focus on what each person has the freedom to do now'	Teacher and graduate Students used in classroom with K-12 students	Teachers used this to help students generate ideas on a science project and to understand science as a series of small contributions in the field.
What, so what and now what	'Together, look back on progress to date and decide what adjustments are needed'	Teachers and graduate student used with K-12 students	This was commonly used by the graduate student and teachers to get the K-12 students to realize and explain an application to their science project.
Wise Crowds	'Tap the wisdom of the whole group in rapid cycles'	In the class room with challenging students or disruptive students	This structure was suggested as a strategy to get a student that was giving problems (i.e., being challenging) a chance to express their expertise or viewpoint to the group.

Across the project, through observation, note-taking by researchers and survey analysis, the engagement was made more enjoyable to all involved and especially for the K-12 students and graduate students working together on projects in the classroom. It was important at every step of this project to get teacher, graduate students, and K-12 students talking about challenges in the classroom, along with challenges in learning, and then applying them to understanding the world around them and their impact on the environment. This increased engagement for the participant allowed us to address pre-conceptions on environmental topics (e.g., all chemicals are fully tested for safety), challenges in the classroom (i.e., time constraints) and challenges with working with younger children (i.e., educational level, behavioral problems). Based on embedded projects during the trainings, teachers had opinions and recommendation on types of liberating structures to use in the classrooms and to use to accomplish the steps of a scientific project. Those recommendations can be found in our previous publication on the use of liberating structures for K-12 education and can better help the reader understand this model of engagement (Ferguson et al., 2015).

V. CONCLUSION

Students that receive early education and training on environmental issues are more likely to choose science careers and become more involved in community environmental issues, and important issues that concern their personal health. For that reason, the project focused on the impressionable ages of 12-17 (Grades 6-12) to build capacity for science, environmental issues, and health through application (i.e., science projects) in Arkansas communities. The development of science projects for the young is crucial for developing critical thinking skills (Thompson, 2011). Although our primary Objective in Arm 1 was to focus on increasing awareness on the environmental topics of IPM and CUR through inquiry based learning (i.e., science projects), the project team discovered that so many K-12 teachers and their students needed increased experience with the scientific method along with opportunities to compete in science fairs in any scientific field of study. Arm 2 allowed us to focus back on IPM and CUR and create a more structured learning format through a 10-day curriculum that included smaller applied projects. Previous projects have shown that students involved in project based curriculums demonstrate greater understanding of science concepts (Harris et al., 2015). Some bias in the program may have existed where more progressive teachers participated in the program to benefit their students and enhance their experiences. This indeed benefited the successful outcomes on this project. However, collaborative projects between Universities and K-12 schools should be encouraged by school districts for all teachers and students to benefit (Shroyer et al., 2007).

For both Arms of the project, implemented activities led to an effective delivery of messages and shared meaning between partners on important concepts expected to better protect the environment and human health (e.g., reduce use of sprays, bombs and foggers in the home, maintaining a clean and dry home, reduce use of personal care products, ventilate while cleaning, and choose less harsh cleaning products for the home), and even on best practices to engage young children on all science topics. With respect to the liberating structures, individuals remember the learning messages because of and in the context of their experiences. Therefore, the method of delivery of environmental education is crucial for retention and action, and in this project we used liberating structures and inquiry based learning through science projects. Success was measured through participation rates, experiences shared through pre and post evaluations, and successes in class, school and regional/university science fairs. Not measured on this project were other long term successes (i.e., creation of more scientists, changes in IM and CUR behaviors in the home). There are plans to promote the curriculum and the 4-hr training through the Arkansas Department of Education, STEM Centers and through the EPA website dedicated to K-12 education.

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