



Applying Liberating Structures (LS) to Improve Teaching in Health and Sciences: Pilot Study Results

Alesia Ferguson^{1*}, Robert Ulmer², Keith Harris³, Ilias Kavouras¹ and Ashley Richison¹

¹Department of Occupational and Environmental Health, Fay W. Boozman College of Public Health, University of Arkansas for Medical Sciences (UAMS), 4301 West Markham, slot 820, Little Rock, AR 72205, USA

²Department of Urban Affairs, College of Professional Studies, University of Nevada, Las Vegas: 4505, S. Maryland Parkway, Las Vegas, NV 89154-3007, USA

³Science, Technology, Engineering and Mathematics (STEM) Center, College of Education, University of Arkansas at Little Rock (UALR): 2801 S. University Ave, Little Rock, AR 72204, USA

*Corresponding author: Alesia Ferguson, Department of Occupational and Environmental Health, Fay W. Boozman College of Public Health, University of Arkansas for Medical Sciences (UAMS), 4301 West Markham, slot 820, Little Rock, AR 72205, USA, Tel: +501 526 6662; E-mail: a Ferguson@uams.edu

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Abstract

Background: Science teachers from multiple kindergartens through twelfth grade (K-12) schools participated in a two-day environmental health training introducing them to newer methods of engagement and interaction adaptable for the classroom environment. This paper describes the use of Liberating Structures (LS) in the two day training for interaction between trainers and K-12 teachers, and the LS structures preferred by these K-12 teachers. These liberating structures are also compared to current engagement and learning techniques or strategies commonly used by teachers in any classroom and to encourage and promote science and health education that could ultimately improve the health and well-being of individuals and families.

Results: Teachers describe the selection of liberating structures they felt would be most useful in a classroom environment for teaching science and health related topics, promoting critical thinking and developing ownership of environmental and health science topics. The most popular structure that appealed to teachers was the '1-2-4-ALL' structure. In general, the teachers felt that this structure could be useful to the critical thinking process as students could use this structure to, first, independently think about a science project idea and then develop this idea in a small and then large group, progressively. "Shift and Share" and 'Impromptu Networking' were also appealing as structures for the scientific inquiry method, where students could be led through the critical thinking process to develop and test a challenging science or health related project hypothesis.

Conclusion: This was a pilot study to look at the potential for use of LS in the classroom and for teaching science and health through improved engagement. Further research is recommended to determine which of these structures are better matched with the scientific method, and education and improved learning in the classroom. Sustained follow-up training for teachers on these strategies is also recommended with more intense training and practice, along with evaluation on using these structures in the classroom. The use and application of these liberating structures in community setting to promote ownership over environmental and health issue is also encouraged.

Keywords: Engagement techniques for the classroom; Environmental; Health and science education; K-12 teacher professional development; Teaching strategies; Management strategies

Introduction

What are liberating structures?

Liberating Structures (LS) have the potential to promote listening, build relationships, encourage open communication and generate ownership of an issue or interest [1]. A "liberating structure" is often referred to as a "destructive methodology," in positive terms, as it destroys prior ways of conducting business, teaching and communicating. Such prior ways of passing on knowledge could include the more traditional formats of using PowerPoint slide presentations in information transfer where the instructor is the only person in the room talking or a business meeting where the employer speaks only of ways to progress the company or gives specific

instructions on resolving a conflict. One example of a liberating structures is called the "1-2-4-All" structure, where participants use a systematic process (i.e., individually and then in growing group interaction) to discuss ideas and concepts that are ultimately refined and shared with the entire group. The use of liberating structures has been successfully applied to many cases and, in particular, conflict resolution [1]. There are thirty-three liberating structures available and described with independent steps for organizing groups and systematic approaches to resolving a conflict or problem, learning from others, promoting a thought process, or coming to a shared understanding [2].

LS encourage the use of writing, listening and talking to improve communication and engagement between individuals and groups and encourage independent thinking and reflection. The key in the use of a liberating structure is giving each person a voice so the final product truly is influenced by all in some way. Some structures may be more effective than others in a particular situation, and it is important for the moderator or instructor to play with the structures and in some

cases merge structures and tailor structures for more effective uses. Developers of these liberating structures encourage adaptations to varying situations to improve engagement and the process of learning and sharing. There has been no specific research on the setting characteristics and their influence on the outcomes from using these structures, given the early development and use of these structures. The general idea is improved strategic outcome in a learning process, a developmental process or improvement in a final product, and choosing the most suitable LS structures to ensure that improved outcome. Outside of anecdotal applications, two published applications of LS were identified. A medical school used LS structures (i.e., “1-2-4-All” and “25 will get you 10”) to develop an action plan to improve student performance on the Medical College Admission Test (MCAT) [3]. Liberating structures (e.g., ‘TRIZ’ and ‘Wise crowds’ were used to change behavior with frontline staff and improve safety standards in the Healthcare industry by breaking silos, and improving engagement on practical solutions [4].

The field of communication has a rich history, where the nature of communication between individuals and groups considers the many fields of sociology, anthropology and psychology and is concerned typically with how people engage in rhetoric to persuade, manipulate or mobilize [5]. When we think of communication, we think of the fields of journalism, media technologies, film, public relations and political science (i.e., mass communication), when in fact, communication is applicable to our daily lives and how we engage with others to accomplish routine undertakings. What we propose here is the application of specific communication tools, i.e., LS, for K-12 classroom instruction and management, to enhance how teachers communicate with students and how students communicate with each other to improve learning outcomes related to science and improving health outcome.

Applying liberating structures to classroom instruction and management strategies

There has been an ongoing interest in the use of various strategies in the classroom that better help students to learn, be this at the K-12 level, undergraduate or graduate studies [6,7]. Marzano et al. have called strategies for K-12 classroom “high probability strategies” [8]. As teachers and educators, we want to ensure that our students stay engaged in the lesson, demonstrate the motivation to learn and then demonstrate how they can apply lessons learned critically to case studies, student science projects, performance measures and, ultimately, in their jobs and lives. Marzano’s work on “Classroom Instruction That Work” lists very broad instructional strategies for the classroom as: (a) identifying similarities and differences, (b) summarizing and note taking, (c) reinforcing effort and providing recognition, (d) homework and practice, (e) nonlinguistic recognition, (f) corporative learning, (g) setting objectives and providing feedback, (h) generating and testing hypotheses, and (i) cues, questions, and advance organizers [8,9]. Marzano also identifies 5 management strategies for the teacher in the classroom: (a) establishing rules, procedures, (b) using effective disciplinary interventions, (c) fostering positive student-teacher relationships, (d) developing an effective mental set and (e) instilling student responsibility [10]. He warns that these various strategies are only a part of a comprehensive program for effective teaching, and in some situations one or more strategies combined work better than others [8]. Others in the field have also developed strategies that may prove useful in classroom instruction and management.

Sometimes the details or mechanics of achieving these instructional or management strategies elude the teacher/instructor. What we introduce here are leadership and communication structures that can provide the mechanics and dynamic format to achieve Marzano’s instructional or management strategies effectively in the classroom, for example. LS can enhance the engagement process between groups of individuals and, more importantly, groups of children and their teachers. In particular, we see value in using these liberating structures to better implement the Marzano’s instructional strategies of (c) reinforcing effort and providing recognition, (f) corporative learning, (g) setting objectives and providing feedback, (h) generating and testing hypotheses and (i) cues, questions and advance organizers. Additionally, LS seem appealing in their application to Marzano’s management strategies of c) fostering positive student teacher relationships and e) instilling student responsibilities. A thorough study of the 33 LS can provide further revelations on how to apply them to many, if not all, of the broad instructional and management strategies in the classroom. Whereas Marzano’s instructional and management strategies are broad strategies for success in the classroom, LS can be seen as routine mechanisms for achieving that success or, simply, more detailed strategies for the classroom to be employed when interacting with the student or for when students are interacting with each other. The Results and Discussion section of this paper will reveal ways in which these structures can be applied in the classroom.

Liberating structures, the scientific inquiry process and argument

What we have discussed so far is the application of liberating structures to general classroom instruction and management. There is, however, added value in specifically applying liberating structures to science lessons in the K-12 setting. The scientific inquiry process requires the student to ask testable research questions and then proceed with designing experiments, analyzing that data, interpreting the results and finding appropriate ways to present and communicate the results [11]. Research has shown great benefit in the use of the scientific inquiry process for k-12 education to promote conceptual understanding [12]. There may be variation to the process and number of steps in the scientific inquiry process (i.e., scientific method), where open or independent inquiry relies more on the student’s own ability to develop questions and design solutions and is harder to achieve than guided inquiry [13]. The teacher’s ability to communicate with the student, get feedback and guide the student through all aspects of the scientific inquiry process with confidence is important for the learning experience. Specifically, the teacher’s ability to engage the student in active thinking is crucial to that critical thinking process [12]. Structured tools and methods of improved communication and engagement in the classroom can prove valuable for this activity, providing the teacher with the means to achieve a higher level of critical thinking and scientific inquiry.

Indeed, for the middle-school student, as they become more independent, the most difficult aspect can be the first step of asking the testable research question and often requires time and effort to go through the critical thinking process. To arrive at a meaningful and testable question, the student needs an opportunity to share an idea and have that idea positively critiqued. Feedback through engagement between the teacher and other students allows for further refinement of an idea and challenges the child to consider and reconsider their perceptions and understanding of science concepts and its application

to a problem (i.e., a health problem). This may also be called a process of constructive argument.

Argument, or the ability to argue effectively, has also been promoted as critical to scientific literacy (and therefore to the scientific inquiry process) where the student can better develop communication skills, metacognitive awareness, critical thinking and an awareness of science as a discipline of investigation and continued discovery [14]. Science is not a simple knowledge subject, and it relies on the teachers to facilitate student engagement in various discussions on science topics and promote better understanding of what we know and what we do not know. The practice of argument seems to be lacking in many science classrooms and author, Cavagnetto, argues that it is critical for understanding the “cultural, social and nature factors” surrounding science and in “establishing valid and reliable information” [14].

A review of the topic of “argument” in 54 articles shows that argument can be used successfully for improving science knowledge construction practices, understanding the interaction between science and society and/or applying newly learned material [14]. Authors, Washburn and Cavagnetto, further encourage argument as a way to integrate science and literacy, where speaking, listening, writing and viewing in an argumentative process are also seen as critical components of science and literacy [15]. We contend that liberating structures can provide structures for applying the argumentative process by ensuring a constructive process of engagement, use of all literary skills and, importantly, a systematic method of inclusion for all. How the teachers organize the group and lead the group in a timely fashion through the critical thinking process is key to managing effective argument. LS are so designed to encourage inner reflection, listening, and arguing in a controlled, systematic and timely fashion, and so great value is applied to the argumentative process.

A Teacher’s prior experience with the scientific method and instructional strategies

A teacher’s positive learning experience in a teacher’s training program with the scientific inquiry process and the necessary skill sets required to lead a student through the process (i.e., how to engage, how to encourage critical thinking, how to lead the student through effective argument) can prove beneficial for the success of their students in the short and long term [11,13]. Not all teachers get this opportunity in their training program, and there is sometimes difficulty in leading younger students effectively through the process.

Paik et al. examined the feelings of 77 teachers, during a professional development (PD) training, concerning their needs and expectations, finding that teachers had a desire to learn more instructional strategies to meet expectations in the classroom including curriculum standards [16]. Where one component of the curriculum standards is getting students to understand and use the inquiry method in science. Some past research on the effectiveness of PD has shown that participating teachers show some improvement in their approach towards inquiry based teaching, using more strategies to engage students in the science topic with greater success in student outcome. The strategies involved more student centered teaching, classrooms observations and constructivist teaching methods [16]. One important aspect of that instructional strategy was to better engage students in their own learning to promote interest and enthusiasm for the science topic. PD programs that focused on curriculum development and examination of practices only show their relationship to teachers’ subsequent use of standard based curriculum

and instruction, really illustrating the combined need to also teach them instructional strategies that would concurrently improve student performance [16].

Objective of the pilot training program

Science teachers from multiple K-12 schools participated in a two-day science training introducing them to LS for classroom science and health applied instruction. The use of LS in the trainings and delivery of science content was a new approach to better engage teachers, get them excited about these environmental and health science topics and explore their feelings and thoughts on using these LS in the classroom environment. Even though an important objective of the pilot program was to look at the effectiveness of the training structure and strategies to successfully impart knowledge on the topics of chemical use reduction and integrated pest management (i.e., designed to promote healthy home and health people) to teachers from diverse science backgrounds, this paper focuses on the potential application of LS in K-12 classrooms to improve the understanding of science and health related topics.

Methods

In training teachers for this program, we used a newer instructional and communication model (i.e., LS) to improve the delivery of environmental and health education messages and to explore the engagement process and collect data from teachers on the use of LS in K-12 education. LS have the potential to promote listening, build relationships, encourage open communication and generate ownership of the environmental/health issue or interest [2]. In this training program, we also wanted to better understand the dynamics of the teaching environment and teacher experiences with engaging students in the classroom on science and health issues. In a practical sense, we also wanted to understand the factors that could hinder or help the transfer of knowledge in the classroom.

The University of Arkansas for Medical Sciences (UAMS) worked through two Science, Technology, Engineering and Math (STEM) Centers affiliated with the University of Arkansas at Little Rock (UALR) and the University of Arkansas Pine Bluff (UAPB) to recruit teachers from multiple schools in diverse communities to 3 sets of trainings. Trainings were four hr on each of two days with a 45-minute break for in-class lunch and socializing. Teachers received eight Professional Development credits from the Arkansas Department of Education. Training presentations and activities were shared by 5 instructors from three Arkansas academic institutes and three departments of various backgrounds: environmental science, K-12 education and communication and speech.

In terms of content topics, Day 1 of the training covered an introduction to LS, science curriculum and an introduction to the science topics of Chemical Use Reduction (CUR) in the home. Day 2 covered an introduction to Integrated Pest Management (IPM) in the home, other healthy home concepts (i.e., seven principles of keeping a healthy home), how to integrate these specifically into the curriculum and a more directed discussion on how to use LS in the classroom, relationships and communication. The science topics of CUR received 1 hr and 15 minutes of specific instruction and IPM received 45 minutes of specific instruction and contained special emphasis on how these science aspects are related to individual, public and environmental health. Results of pre and post surveys based on these scientific topics have been published elsewhere [17].

A variety of LS were used interactively with the teachers throughout the training to engage them in the newer science topics, discuss the uncertainties in these science topic areas, explore teachers' feelings and opinions on all topic areas and solidify main concepts. Ultimately, we were demonstrating the use of liberating structures interactively and stimulating discussion of their application in K-12 classrooms. Teachers were also given an overnight assignment on Day 1, to study the Liberating Structures' brochure, visit the Liberating Structures' website and present the next day on what they thought would be useful formats to adapt to K-12 classrooms when delivering and teaching environmental health topics, such as those covered in the training, and in working with the students on science projects. They were also encouraged to think about how else these structures could be useful in their work environment.

The training also explored teachers' prior training or use of the scientific method and reminded them of the standard steps of accomplishing the scientific method in the classroom and the importance of promoting practice with the scientific inquiry process. The scientific method can be viewed as an iterative process from (a) developing the testable science idea, (b) conducting the research on background information, (c) developing a hypothesis, (d) designing and conducting the experiments, (e) conducting analysis and presenting data, (f) drawing conclusions and (8) addressing limitations. They were also encouraged to more rigorously work with their student on science projects for competitive entry into regional science fairs and were provided with information on requirements for entry.

Teachers received folders with learning and information sheets on the science topics and four brochures developed for this project. Brochures addressed the specific topics of the program: "Chemical Use Reduction," "Integrated Pest Management for Homes," "Liberating Structures for Environmental Education" and "Developing a Science Project." Brochures were developed to refine messages in the format we felt ideal for this project and simplified for sharing with students in their classrooms. Instructors gave prior thought to the use of each liberating structure with the teachers during the training in terms of required room space and timely organization of participants in order to effectively lead them through the learning, and sharing process. Simple tools were required to lead teachers through the application of various LS, and these included note paper, sticky notes and pens for the teachers and whiteboards for the Instructors.

A pre-and post-survey were delivered to the participants, and even though it was focused on the effective delivery and understanding of the science topics covered, the surveys also included questions on the teachers' prior experience with LS and their overall experience with using the structures. A research assistant recorded teacher feedback during the instructors' use of LS interactively and during the presentations given by each teacher on their personal thoughts and potential applied use of LS.

There were some changes made from Year 1 to Year 2 in the training and engagement format. Instructors interactively used additional LS in Year 2 in order to improve the training content and allow teachers to experience a broader context for applying a variety of LS. In addition, Year 2's improved format allowed teachers to first discuss and engage with each other about a science topic or on a training content area prior to the Instructors' lectures on the topic area. This permitted teachers to work more in groups building trust and understanding, and this allowed them to reveal prior perceptions, feelings and understanding of a topic area. In this manner, they would stay more

engaged in the process and instructors could more effectively gauge their feelings and address prior misconceptions.

Results and Discussion

Demographics

The majority of the 70 attendees over the two-year program were female (81%), which is likely typical of the classroom female to male teacher ratio, with 61% being White (Table 1). There was an even distribution of ages from 20 to over 50 years old. The major subject expertise was in the sciences, as expected. However, we did not exclude the attendance of other teachers from other subject areas. In some cases, as Table 1 indicates, teachers taught more than one subject depending on the size of school and school structure and expectations. We primarily targeted teachers from Middle schools (5th to 9th grade) but had Grades 2 through the 12th Grade (ages 7 through 18). Teachers came from 46 different schools, mostly from the Pulaski County and Jefferson County school districts. Based on the results of the pre-survey for all teachers, this was the first introduction to the use of LS in the classroom setting or in any other context.

Demographics		
Gender	Female	57
	Male	13
Age	20-30	7
	31-40	19
	41-50	18
	>50	24
	No response	2
Race	Black	22
	White	43
	Other	3
	No response	2
Years of teaching experience	0 (this was a teacher in training)	1
	1-5	15
	6-10	18
	11-15	11
	>15	23
Subject expertise (teachers listed more than one area of expertise)	Science	43
	Physics	1
	Lab Science	2
	Chemistry	2
	Math	8
	Physical Science	4
	Life Science, Integrated Science	4

	Environmental Science	3
	Language, History	2
	Engineering, Robotics	3
	Anatomy, Biology, Physiology	3
	Social Studies	2
	Technology	1
	All Subjects	7

Table 1: Demographics for All Teachers in Training. Note: Subject expertise will total more than 70, where teachers are responsible for multiple subjects Immersing Teachers in the Active Use of LS.

The most effective way to introduce teachers to LS was to immerse them through active participation in their use. Table 2 and Table 3 illustrate the specific LS used in Year 1 and Year 2, respectively, and the context and purpose for that liberating structure in the training. In Year 2, additional structures were used during the two-day training to more intensely engross teachers in the training experience. Use of LS increased from 4 to 7, from the first year to the second year, and, typically, the liberating structures proceeded discussion of a science/engagement topic in the second year as a change to improve the engagement process and better address initial perception or misunderstanding.

The structures of “1,2,4 –ALL” and “Impromptu Networking” are two very popular and simple to apply LS used on both days. Whereas ‘1,2,4-All’ requires more structure, planning and time periods of individual reflection, ‘Impromptu Networking’ is a more spontaneous structure of immediate engagement and sharing of ideas. Use of any of the these structures illustrated in Tables 2 and Table 3 always ended with a full group discussion with instructors over what was discussed, what discoveries were made, what main themes emerged and their

Liberating Structures	Usage Year 1 Training
Impromptu Networking	Teacher used open space and milling to talk about how they could integrate applied science topics pertaining to health and environmental into the science curriculum.
1-2-4-All	Teachers used this individual and growing group structure to take about the use of the pre-cautionary principle and to compare the risk of chemical use around the home to the risk of being a victim of a drinking and driving and home falls.
What, So What and Now What	In small groups that shared later with a larger group, teachers discussed the simple aspects of integrated pest management that were easy to implement immediately in the home, and whether practicing IPM around the home was a waste of time.
TRIZ	Teachers discussed the difficulties children encounter in learning science effectively in the classroom and in particular any obstacles to integrating chemical use reduction and integrated pest management concepts into the science curriculum.

Table 2: Use of liberating structures in year 1.

Throughout the training the teachers were meant to comprehend that by allowing each child to contribute, the teacher could create a constantly dynamic atmosphere where response and outcomes evolve and shape the teaching and learning experience. Again, because these are structures with time elements and meaningful and deliberate prompts for each person’s contribution and for group discussion, the teacher can still control the activities to achieve desired learning

experience in using the structures. Instructors always milled around the room to ensure proper use of structures and appropriate use of time. All teachers seemed to enjoy the process and stayed alert through the two-day experience. Instructors encouraged varying individuals to share back to the larger groups, giving even those who appeared shy an opportunity to engage. The idea behind these structures is that everyone at some point had an opportunity to listen and speak.

One of the many shared experiences was to discuss and talk about five chemicals the participants thought were harmful in the home environment and five other chemicals that they thought would not be harmful. In Year 2 (Table 3), the 1-2-4-All Liberating Structure was used for this process. After summarizing the general results of the entire group, a training Instructor then talked about toxicity and risk in terms of properties of chemicals, reactions in the environment, duration and extent of exposures and the use of precautionary principle when adequate information was not currently available to discern the potential impact of a chemical’s use on the environment and on human health. This was a strategy to get teachers thinking about their own prior knowledge and the chemicals they listed under each group, promote critical thinking on the topic of chemical use reduction and, ultimately, have them more engaged in the learning process. In Year 1 (Table 2), the ‘1-2-4-All’ Liberating Structure was used in a comparative manner to have teachers discuss risks from the use of harsh chemicals in the home to the risks of drinking and driving along with discussion on the precautionary principle. In Year 1, teachers first listened to the lectures on CUR before their engagement activity; their very positive comments on being highly cautious about chemical use around the home may have been influenced by the lecture and not prior feelings and misconceptions. Another shared experience in Year 2 was to have teachers say what they hoped to get from the training and what they hoped to give. This allowed us to adapt the training more dynamically to the needs of the group and, in some cases, explain what the training could not do for them but discuss other opportunities that might exist.

objectives but be more successful at engaging the class in the learning process and improving educational outcomes. Some research has shown that in a system’s design approach where students begin with their own needs and ask their own questions, more success is shown in motivation and engagement than in a scripted inquiry approach and, in particular, is beneficial for schools with students having low social economic status with typically low achievement levels [18].

Liberating Structures	Usage Year 2 Training
Impromptu Networking	Teachers used open space and milling to introduce themselves and discuss 2 things they hoped to get from this training and 2 things they hope to give.
Agreement and Certainty Matrix	Teachers used post it to categorize learning and teaching challenges in the classroom into simple, complicated, complex and chaotic categories on a group chart
15% Solution	Teachers were asked to share in groups what their personal challenge was in the classrooms and what they could do now to solve the problem without additional resources of authority. The idea was, could they make a change in their job or classroom to improve outcome.
1-2-4 All	Teachers used this individual and growing group structure to take about the use of the pre-cautionary principle and 5 chemicals they considered safe and 5 chemicals that they considered not safe to use around the home
What, So What and Now What	In small groups that shared later with a larger group, teachers discussed the simple aspects of integrated pest management that were easy to implement immediately in the home.
Design Story Board	Teachers worked in groups to design a science projects and demonstrate elements of the scientific method.
TRIZ	Teachers discussed the difficulties children encounter in learning science effectively in the classroom and in particular any obstacles to integrating chemical use reduction and integrated pest management concepts into the science curriculum.

Table 3: Use of liberating structures in year 2.

Evaluating the potential use of liberating structures in k-12 education

In both years, teachers had an overnight assignment they would present in the morning of Day 2. They were to choose one or two of the LS that appealed to them for use in their classroom as a teacher. They were instructed to read the LS brochure, study the website, including examples of their application to other areas and fields, and reflect on how we used LS that day in the training to engage them. There was no specific guidance as to which of the structures were applicable to scientific inquiry but were advised instead to generally consider how they could use these structures for what they considered more effective instruction on the teacher’s part and more effective learning on student’s part. The idea was to promote improved outcomes in the classroom environment. We encouraged them to comment on structures that appeared familiar to teaching techniques, strategies they already used in the classroom, and structures that appeared easy to implement. We also promoted some consideration of how these structures could be used to resolve conflict at any level and even administratively.

Table 4 is a combined summary of the liberating structures the teacher’s chose to present in both years and how they felt these structures could be applied in the classroom and, in some cases, outside of the classroom (i.e., we describe the main themes in the table). The table also contains the main structural idea behind each liberating structure as summarized from the developer’s description [1]. Occasionally, teachers mentioned more than one structure that appealed to them. Naturally, we expected their choices to be influenced by LS we used that day, and, in fact, the most popular structure that appealed to teachers was the ‘1-2-4-ALL’ structure. In general, the teachers felt that this structure could be useful to the critical thinking process as students could use this structure to, first, independently think about a science project idea and then develop this idea in a small and then large group, progressively. Many of the structures chosen by

the teachers were appealing to the scientific inquiry method. “Shift and Share” and ‘Impromptu Networking’ were, for example, structures appealing for the scientific inquiry method, where students could be led through the critical thinking process to develop and test a challenging science project hypothesis.

Teachers in the first year of training were notably attracted to the “Drawing Together” structure, where 7 found it an appealing structure. A review of the registration information in Year 1 shows that many of the teachers also taught younger students down to the 2nd Grade. ‘Drawing together’ was appealing due to its use of non-verbal symbols to express thought, and many teachers mentioned that younger children were often shy and could not effectively verbally express themselves. ‘Drawing together’ would allow a first impression of a child’s thoughts upon which the teacher and other students in the group could build. It was an activity in which they could enjoy and stay engaged. The popular family and friendly game of “Pictionary” brings to mind an entertaining and engaging experience in the home. “Celebrity Interview” was mentioned useful in two contexts. As shown in Table 1, teachers thought students could use this to role-play a career in which they would be interested, but this could also be used to invite guest speakers in areas of science to engage the children and allow them to see science in the field and as a career.

There are some other appealing strategies, and those include “Wise Crowd” and “15% Solution.” One teacher found ‘Wise Crowd’ extremely attractive in its potential to allow a disruptive child to get the chance to show what they know and answer challenging from other children and the teacher. The structure of the ‘15% Solution’ structure was appealing to the teachers in the development of science project ideas and potential experiments towards a solution. This would allow the student to grasp the idea that in science, complete and full solutions are not immediately available, but, in fact, science is a progressive combination of steps towards discovery.

S.NO	Liberating Structures	n	Main Structural Idea	Example application in the Classroom
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1	1-2-4-ALL	14	Engaging Everyone	Students gradually develop critical thinking alone and in groups, getting reluctant child to engage, compared to 'first and five'
2	Drawing Together	9	Revelation through Non-Verbal Expression	Students use symbols to solve problems, use in biology for adding details to human systems or organs (i.e., drawing heart, lungs structures), for example
3	Conversation Cafe	7	Relaxed Engagement	Students get to know each other, and develop social skills
4	Celebrity Interview	7	Using Experts	Students assigned a challenging role and research the part
5	Impromptu Networking	6	Rapidly Build New Connections	Students bounce ideas back and forth, similar to clock partners and use of talking stick
6	Wise-Crowds	4	Cycles of Tapping Wisdom	A student child get an opportunity to show what they know
7	What, So What, Now What?	5	Adjusting as Necessary	Students make connections between subject ideas, moving to application, resolving environmental issues over time
8	Shift & Share	8	Spreading Good Ideas	Student rotate in groups in learn from each other. Integrate with 'jigsaw' strategy for the classroom
9	Appreciative Interviews	4	Discover and Build	Interview student on knowledge of a topic to ensure success
10	9 Whys	4	Clarifying Purpose	Students learn through self-discovery
11	User Experience Fish Bowl	6	Sharing Experience	Students ask more knowledgeable children questions, use of older children in the middle circle, similar to 'socratic circle'
12	Discovery and Action Dialogue	4	Discover, Spark and Unleash	Students talk about different ideas with peers and clarify concepts
13	Mini Specs	2	Purposeful Do's and Don'ts	Children come up with the rules for a topic
14	TRIZ	2	Making Space for Innovation	Students express negative views and learn to resolve conflicts
15	Heard, Seen, Respected	1	Listening and Empathy	Getting input from each student to create welcoming atmosphere
16	Social Network Webbing	1	Strengthen Network	Students use poster boards for cross curricular activities
17	Design Story Boards	2	Defining Elements for Productivity	Students use stories to connect concepts
18	Wicked Question	1	Paradoxical Challenges	Students look at pros and cons of a subject
19	Improv Prototyping	1	Effective Solutions to Chronic Challenges	Students act out a scenario for critical thinking
20	Agreement-Certainty Matrix	2	Sorting and Addressing Challenges	Student organize subject topics from easy to hard
21	15% Solutions	1	Focus on Each Person's Contribution	Students learn to come up with small and simple solutions
22	25-To-10 Crowd Sourcing	1	Generate Powerful Ideas	Students rate other student ideas and discuss avenues for improvement
23	What I need from You	3	Getting Support	Teacher emphasizes student responsibility to promote listening, establishing playground rules and resolving conflict out of the classroom, for working with multiple groups.

Table 4: Teachers' Feelings on Applying Liberating Structures in Classroom. Note: Teachers were allowed to choose more than one structure and in some suggested ways to merge structures. Some previous teaching structures were alluded to including "Fist and Five," "Teaching Stick," "Jigsaw," and "Socratic circle."

Conclusions

The responsibilities of teachers are immense. Teachers are primarily expected to educate their students and pass on a wealth of knowledge in many subject areas of K-12 education; this means teachers are largely pre-occupied with fulfilling mandated curriculum standards [19]. But, teachers are also expected to create critical and rational thinkers, and teachers are expected to instill social and moral values with the long-term goal to create responsible and successful citizens that contribute to the society in which they live, ultimately to improve the standard of living for the human race. Teachers must achieve these expectations while managing the many personalities they encounter, all while coping with time constraints in the classroom.

More recently, a number of states, including Arkansas, have required teachers to receive professional training in teaching students with learning disabilities or challenges. For example, Act 1294, through the Arkansas 2013 State Legislature, mandates the requirement for teachers to receive training in dyslexia, recognizing the many challenges teachers experience in the classroom [20]. Here, we have presented LS that can be applied to improve teaching and management strategies in the classroom, allowing teachers to better cope with the immense expectations and diverse populations of students.

Some similarity exists between Kagan structures, i.e., cooperative learning structures, developed in the 1970s and used routinely in the classroom (e.g., Pair and Share) and the LS presented here [21]. During the training, teachers often mentioned some of these structures they have used in the classroom. Kagan structures revolve around methods to promote equal involvement and concurrent interaction in the classroom with children, not unlike the intent of LS originally developed for adults to resolve conflict and move towards solutions.

Berland in looking at scientific argumentation in a classroom found that traditional classroom practices limited student interaction and opportunities of working collaboratively and understanding varying perspectives [22]. Therefore, LS and Kagan structures, if used more routinely, may offer improved opportunities for critical thinking in the classroom setting, engagement and improved learning outcomes, in essence, promoting the cognitive, metacognitive and motivating aspects of self-regulation important for and health science education as described by Schraw and company [23]. It is critical to encourage an early age ownership and responsibility over the environment and one health. These structures offer an opportunity to excite children about these critical topics.

Research has also explored the capability of a positive school climate to promote the well-being of its students, where school climate is based on fostering the many relationships that exist and establishing certain norms, values, teaching and learning styles. Positive school climates appear to promote student performance, creating the environment in which students feel engaged and possess the motivation to learn [24]. Marzano has also spoken about the three main critical commitments needed for school improvement reform. These include: (a) building background knowledge for all students [including those with academic deficiencies], (b) providing effective feedback to student at the district, school and classroom level and (c) ensuring effective teaching in every classroom [25]. The LS described here are used to promote communication and enhance classroom and organizational performance and can be used to shape school climate and help parents, teachers, students and administrators work towards a shared purpose. Many of the teachers in our training program seemed particularly concerned about what they could achieve in the classroom based on

their poor relationship with school administration. Liberating structures provide a variety of tools to promote that engagement at the administrative level and in the teacher-parent relationship, in addition to their application to learning and teaching activities that occur in the classroom.

This was a pilot study to look at the potential for use of LS in the classroom and for teaching science and health through improved engagement. Further research is recommended to determine which of these structures are better matched with the scientific method and to develop other specific applications (i.e., health and beyond) for improved learning in the classroom. Sustained follow-up training for teachers on these strategies is also recommended with more intense training and practice using these structures in the classroom. Research on the use and application of these liberating structures in community setting to promote ownership over environmental and health issue is also encouraged. Improving engagement of individuals and community on their health through a thoughtful process of communication as implied through the use of liberating structures should be explored.

Competing Interest

None of the authors have competing interest.

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