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Breaking the Chains that Prevent Student Comprehension: Exhuming and Rectifying Common Chemistry Misconceptions through Music

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Breaking the Chains that Prevent Student Comprehension: Exhuming and
Rectifying Common Chemistry Misconceptions through Music

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Chapter One: Introduction

Gases do not have mass, air and oxygen are the same gas, objects float in water because they are lighter than water, materials can only exhibit properties of one state of matter, and boiling is the maximum temperature a substance can reach are only a few of the common misconceptions students have when it comes to the subject of chemistry. Regardless of how students construct these alternative conceptions within chemistry, they serve as significant barriers to scaffolding of proper knowledge. Just as any structure must be built upon a solid foundation, student knowledge must be constructed upon an underpinning of core facts and concepts. Unfortunately, when these facts and concepts are false due to some misunderstanding, proper scaffolding of knowledge ceases.

Galindo (2017) states that our initial beliefs about the world, prior to receiving any formal education, are called naïve theories. Based on our particular life experiences, we develop naïve theories about everything we come into contact with. But our brains take lots of shortcuts along the way—we look for patterns and quickly jump to conclusions, and this emphasis on efficiency costs us accuracy. Learned early, naïve theories are incredibly hard to extinguish; even in the face of conflicting information that we may later be exposed to (Galindo, 2017). In a chemistry classroom, this has noteworthy implications. Naïve theories, such as gases do not have mass, are difficult to rectify. From the perspective of the student, these naïve theories are believed to be factual, and therefore challenging to alter. For example, the belief that gases do not have mass would impede student comprehension of content dealing with states of matter or the colligative property of vapor pressure.

Misconceptions are not unusual among students; in fact, they are very commonplace in the minds of students, and are an ordinary part of the learning process (Lucariello & Naff, 2017).

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These alternative conceptions, or misconceptions, are gained and established through a student's prior instruction and everyday experiences. Unfortunately, these newly formed concepts and theories are incorrect on a factual level and must be addressed so that deeper (and proper) understanding can be achieved. The importance of addressing student misconceptions cannot be overstated. Misconceptions are very important in the learning process and they have to be taken into account when teaching science. These misconceptions can interfere with students' learning of scientific principles or concepts (Pekmez, 2010, p. 3). Therefore, it is vital for teachers to first, identify the misconception, and second, correct the misconception (Colburn, 2009, Suaalii & Bhattacharya, 2007, Taber, 2011). Misconceptions can be exhumed in a number of ways. One opportunity that chemistry teachers have is by pre-assessing the students' knowledge of concepts before beginning a new unit. Assessing what students think they know before introducing new material can reveal misconceptions they have and can lead to productive individual or group discussion. Mayer (2010) states that many researchers have chronicled the misconceptions students have and how important it is to address these misconceptions, but it is difficult to find any research that suggested exactly how to address them. Overtly identifying the misconception and having practical dialog with students regarding the false nature of the misconception is the first step breaking the chains that they have on comprehension. Educational resources, such as conceptual change texts and computer animations/simulations, have been shown to be effective tools to aid in these discussions.

Chemistry is a very abstract discipline by nature, and this creates challenges for student comprehension (Barthlow & Watson, 2014, Beerenwinkel, Parchmann, & Gräsel, 2011, Colburn, 2009, Sirhan, 2007). To makes sense of content they don't entirely understand, students form misconceptions to rationalize what remains confounding within a given topic. Beerenwinkel,

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Parchmann, & Gräsel, (2011) state that students are assumed to construct mental models to solve problems. The formation of these models is supposed to be constrained by the individual's prior knowledge. When learners are confronted with a piece of information that conflicts with one of their presuppositions or beliefs, it is suggested that instead of changing the prior assumption, a so-called synthetic model is formed. This mental model satisfies both the new piece of information and the respective prior presupposition or belief. Synthetic models thus reflect consistent knowledge. However, they are faulty from a scientific perspective and thus called misconceptions (Beerenwinkel, Parchmann, & Gräsel, 2011, p. 1237).

According to the National Academies Press, there are two types of misconceptions: vernacular misconceptions and factual misconceptions. Vernacular misconceptions arise from the use of words that mean one thing in everyday life and another in a scientific context. For example, substitution of the word "melt" for "retreat" helps reinforce the correct interpretation that the front end of the glacier simply melts faster than the ice advances. Factual misconceptions are falsities often learned at an early age and retained unchallenged into adulthood. An example of a factual misconception could be a young child observing a branch floating in a creek and rationalizing that this is due to the branch being lighter than the water. After many years of accepting this to be true, that same individual may struggle with the notions of density or buoyancy being responsible for the ability of branch to float. Given the use of an abundance of content specific vocabulary (vernacular) and the abstract nature of chemical concepts (factual), students enter the chemistry classroom with a multitude of both types of misconceptions.

The major drawback is that these misconceptions can become embedded into a student's thinking and hinder learning. Sirhan (2007) states that concepts develop as new ideas are linked

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together and the learner does not always correctly make such links... this may well lead to misconceptions. Sirhan (2007) suggests conceptions or pieces of intellectual thought either reinforce each other or act as barrier for further learning. Students are not aware that their current perspective is incorrect and therefore will resist reshaping their viewpoint. New experiences are viewed and interpreted through a flawed lens; which interferes with scaffolding proper knowledge. Misconceptions are difficult to alter through instruction because the process of learning involves restructuring the students' current knowledge (Lucariello & Naff, 2017). For instance, a student who believes that all metal objects sink in water would predict that a paperclip will sink to bottom of a beaker of water due to this flawed lens. However, upon performing this quick experiment they will observe the contrary. Regardless of this observation, the misconception can persist due it being deeply embedded into the student's current knowledge construct. This is evidence that misconceptions are very stable within student knowledge and can hinder deeper comprehension and achievement, making it difficult for conceptual change to occur.

Traditional methods, such as "conceptual change texts" and "computer animations" have been shown to be effective in fostering conceptual change in students. One area in which research is limited is in the use of music, in both addressing student misconceptions, as well as, fostering conceptual change in students.

This paper will examine the complexities that students experience when learning chemistry and the historical context of misconceptions. It will discuss the notion of conceptual change, how research has shown it can be achieved, and propose the innovative use of music as a means of promoting it. Relevant theories to addressing and correcting misconceptions in the

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classroom (e.g. metacognition, the 5E learning model, argumentation, and active learning) will also be explored.

Chapter Two: Review of Literature

Complexities of Learning Chemistry

3 Levels of Chemical Knowledge

Chemistry is full of abstract concepts, but the thing that distinguishes chemistry from other subjects that students learn in high school is that it is learned on 3 distinct levels (Beerenwinkel, Parchmann, & Gräsel, 2011, Gabel, 1999, Sirhan, 2007). Sirhan (2007) states chemical knowledge is learned at three levels: “sub-microscopic,” “macroscopic” and “symbolic”, and the link between these levels should be explicitly taught. The interactions and distinctions between them are important characteristics of chemistry learning and necessary for achievement in comprehending chemical concepts. Therefore, if students possess difficulties at one of the levels, it can influence understanding of another level (Sirhan, 2007, p. 5). Another layer to the complexity of learning chemistry is the incorrect application of concepts between these levels of chemical knowledge. Students may create misconceptions by applying macroscopic understandings to their submicroscopic understandings (Beerenwinkel, Parchmann, & Gräsel, 2011, p. 1240). The primary barrier to understanding chemistry, however, is not the existence of the three levels of representing matter. It is that chemistry instruction occurs predominantly on the most abstract level, the symbolic level (Gabel, 1999). Therefore, educators need to develop methods of relating abstract content to experiences or concepts that students can readily observe. This practical knowledge can be used to make analogies to content that cannot be easily seen firsthand by the student. Computer animations have been shown to be an effective way of presenting such material (Cepni & Şahin, 2012). In their study, Cepni & Şahin (2012) document improvements in student comprehension of abstract concepts such as gas pressure, volume, and interpretation of the ideal gas law through use of computer simulations.

Overload of Student's Working Memory Space

Sirhan (2007) suggests that in addition to the complexities of learning chemistry, two other factors affect the formation of misconceptions: overload of students' working memory space and the use of content specific language. The volume of an individual's working memory space is of limited capacity. This limited shared space is a link between, what has to be held in conscious memory, and the processing activities required to handle it, transform it, manipulate it, and get it ready for storage in long-term memory (Sirhan, 2007). When students are faced with learning situations where there is too much to handle in the limited working space, they have difficulty distinguishing the important information from the less important information. This creates an opportunity for focus to be placed on peripheral content instead of the key concepts important to scaffolding proper knowledge. This misplaced focus due to memory overload can lead to the formation of student misconceptions (Sirhan, 2007).

Content-Specific Language

Language has been shown to be another contributor to the formation of student misconceptions. Sirhan (2007) states that language influences the thinking processes necessary to tackle any task. When complex, content-specific vocabulary confuses a student, they are prone to make improper connections in an effort to establish some level of comprehension. Language problems include unfamiliar or misleading vocabulary, familiar vocabulary which changes its meaning as it moves into chemistry, use of high sounding language, and the use of double or triple negatives (Sirhan, 2007, p.7). Content-specific language is rampant within the discipline of chemistry. The atomic and sub-atomic worlds are extensive with their use of jargon. It is easy for

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students to create misconceptions when they do not have a working knowledge of the material and become befuddled by the language used to discuss and describe it.

Chemistry curriculum builds upon itself and introduces students to a plethora of information and content specific vocabulary that they must quickly digest so that they can understand current (as well as future) concepts. Problems can arise when this flood of new information overwhelms the students' working memory. As a result, they struggle to make proper connections and what information they should focus their attention upon... thus creating the potential for misconceptions to be formed and embedded into their knowledge.

Historical Context of Misconceptions

The Behaviorist Era

The events that lead to the Behaviorist Era date back to the late 1800s. According to Herron (1999), behaviorists reasoned that, with no way to observe the mind directly, it was best to describe learning in terms of stimuli that impinge on our senses and the observed responses to those stimuli. Behaviorist theories describe knowledge as being an entity that has an existence of its own. Knowledge is "out there" and the teacher's job is to get it inside the students' heads. Teachers transmit knowledge by providing the appropriate stimuli and conditioning students to respond appropriately (Herron, 1999, p. 1354). The teacher is the dominant figure within the classroom and lectures to subservient students who listen quietly and take notes. Students, in the behaviorist view, are objects manipulated by instructors or programmed materials. This idea is directly related to the notion of operant conditioning developed by B.F. Skinner in 1937, where he found that behaviors could be shaped by rewarding desired behavior, while punishing undesired behavior. From an educational perspective, students receive information from experts and respond with answers that are rewarded (Herron, 1999, p. 1354). The implications of a

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lecture-heavy presentation of content within a chemistry classroom are that students are introduced to concepts that cannot be readily seen or observed firsthand. Merely discussing the nature of symbolic level material via lecture can lead to improper connections between ideas and the formation of misconceptions. In addition, students can be (and many have been) conditioned to give proper responses in a quest for good grades, but at the expense of accurately understanding the basis of those responses.

The Dawn of Constructivist Approaches

As accumulating evidence from research and experience revealed that students could indeed be trained to provide acceptable responses without understanding, the behaviorist based paradigm gave way to information processing and constructivist theories (Herron, 1999, p. 1356). Herron (1999) adds that this shift coincided with a growing awareness and understanding of psychological theories of intellectual and cognitive development such as that developed by Jean Piaget. Piaget, considered the father of constructivist theory, postulated that people construct knowledge through a combination of their experiences and the knowledge they already possess. Constructivism asserts, “knowledge is not passively received but is actively built up by the cognizing [learner] and shifts attention from what the teacher or program does to what goes on inside the learner (Herron, 1999, p. 1356). Students interpret what they hear and read in light of what they already know; constructing knowledge...that fits their understanding of the world (Herron, 1999, p. 1356). Therefore, drawing upon student prior experiences and knowledge is an important part of the learning process. Because chemistry concepts build upon one another, students must first have a good factual foundation to construct chemical knowledge and deepen comprehension. This further illustrates the need for educators to identify and address misconceptions... otherwise, proper construction of knowledge cannot occur.

Conceptions and Misconceptions

If students mentally “construct” knowledge, the building blocks are their conceptions. Conceptions (or pieces of intellectual thought) either reinforce each other or act as barrier for further learning (Sirhan, 2007). Students’ prior expectations, existing schema and conceptions about the topics being taught and their understanding can potentially hinder their conceptual development in chemistry (Suaalii & Bhattacharya, 2007, p. 101). Students hold a wide range of ideas related to chemical phenomena. Studies have shown that these ideas and misconceptions can be specific, very stable, related to other ideas... or they can be general and not coherently related to others (Suaalii & Bhattacharya, 2007, p. 101). The authors go on to state that studies have shown that students may hold numerous misconceptions in many areas of chemistry and many of these misconceptions are not changed by further instruction due to students’ inability to interpret and understand the chemical phenomena at a sub-microscopic level of representation. The steadfastness of misconceptions causes them to be quite troublesome as students seek to make sense of increasingly more complex and abstract material. As students attempt to scaffold proper knowledge, the continued presence of a misconception they have related to that content can halt comprehension, lead to further confusion, or lead to additional misconceptions.

To overcome these obstacles in learning, student conception researchers have been focusing on identifying and assessing students’ “misconceptions” (Sirhan, 2007, p. 8). It is vital for the teacher to know what the learners already know and how they came to acquire the knowledge. Many students come to a class with wrong ideas, confused ideas or even a complete lack of background knowledge. According to Cullen & Pentecost (2011), instructors must be aware of the misconceptions that students have about specific chemistry topics. Cullen & Pentecost (2011) encourage chemistry instructors to research the topics and survey student

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knowledge before beginning instruction. In addition, learning experiences need to be offered to prepare students to grasp new material by clarifying or correcting previously held concepts or by providing fundamental instruction on such concepts. It is important to take into account the way the learner gains knowledge and to present material in a way that is consistent with patterns of human learning (Sirhan, 2007, p. 8). One way in which teachers can survey students' prior knowledge is through a variety of pre-assessments administered before introducing new material. These include responses to prompting questions, filling out entrance/exit tickets, or conducting group discussions. Only when a misconception is identified and addressed can conceptual change occur within the student.

Conceptual Change

What is Conceptual Change?

According to Beerenwinkel, Parchmann, & Gräsel, (2011) conceptual change processes can roughly be defined as learning paths from everyday conceptions or alternative ideas which have been developed under instruction towards scientific concepts. Ideas are combined and integrated into a broader network of conceptual explanations. Conceptual change involves the revision, modification, or replacement of an individual's naïve theories and mental models (Talanquer, 2009, p.2). Conceptual change research is concerned with the questions how misconceptions develop and how they can be addressed in instruction (Beerenwinkel, Parchmann, & Gräsel, 2011, p. 1236). Most of recent research regards conceptual change no longer as an exchange or replacement of ideas as it was interpreted at the beginning of conceptual change research. It is rather assumed that different concepts can co-exist (Beerenwinkel, Parchmann, & Gräsel, 2011, p. 1237). The authors go on to say that this

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perspective assumes that students do not generally abandon their previous ideas but that new concepts are added and connected in multiple ways with their prior knowledge. There is an overall agreement that conceptual change does not refer to a simple kind of learning such as a mere addition of facts. It is rather regarded as a learning process in which conceptual structures ... have to be fundamentally restructured in order to allow understanding of the intended content (Beerenwinkel, Parchmann, & Gräsel, 2011, p. 1238). This explains why further instruction is not effective in addressing and correcting misconceptions. The fact that ideas are not just replaced within student knowledge elucidates that concepts are inter-connected on multiple levels and must be properly integrated into student knowledge. Therefore, to fully address and correct a misconception is to facilitate conceptual change within previously scaffolded knowledge.

How do we as educators foster the process of conceptual change with our students? According to Beerenwinkel, Parchmann, & Gräsel (2011) the question of how to engage students in conceptual change processes is answered by subjecting them to a cognitive conflict. When faced with a cognitive conflict, students are presented with anomalous information with the goal of motivating them to question their current concepts and to think about alternatives for explaining the phenomenon.

Traditional Methods of Fostering Conceptual Change

What are some traditional methods teachers have used to help facilitate conceptual change? Cepni & Şahin (2012) researched the use and effectiveness of conceptual change texts, concept cartoons, and computer animations.

■ **Conceptual Change Texts**

The results of Cepni & Şahin (2012) showed that using a conceptual change text is effective in overcoming students' alternative conceptions because it activates the students' misconceptions, presents common misconceptions, and tries make the learner comprehend explanations that are scientifically accepted. Beerenwinkel, Parchmann, & Gräsel (2011) state that texts which present and refute misconceptions support students better in understanding the scientific content than reading common, non-conceptual change texts. The main difference between the conceptual change and the traditional texts are the way in which misconceptions were taken into account. Although the traditional text addressed some common misconceptions, the conceptual change text had more detailed and longer passages that discussed the misconceptions. Whereas the traditional text addressed some misconceptions in a rather indirect or abstract way, the conceptual change text addressed misconceptions explicitly. The conceptual change text additionally provided comprehensive explanations why such ideas are regarded as misconceptions. Headings within the conceptual change text also tried to focus students' attention to the disparity or overlap between their own ideas and the scientific view (Beerenwinkel, Parchmann, & Gräsel, 2011, p. 1247). Utilizing a text that helps bring these false theories and misunderstood concepts to the surface is an effective way of starting the conversation of what students "think" they know. In addition, it is through engaging the student in fruitful discourse regarding the false nature of the misconception and what it is they "should" know that the misconception can be properly addressed. Beerenwinkel, Parchmann, & Gräsel (2011) suggest the following criteria in designing a conceptual change text:

- **Challenge misconceptions explicitly:** 'What is between the particles? ... Is there air between the particles?'

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- **Refer to everyday life:** ‘You certainly know about vacuum-packed food or vacuum pumps ... In everyday life, however, we observe that there is air is between all objects.’
- **Give metaconceptual prompts:** ‘Hence, what is between the water particles? How did you think of it before?’

Another form that conceptual change texts can take are informal cartoons. The concept cartoons used by Cepni & Şahin (2012) consist of illustrations that address alternative concepts in science by introducing them as short texts with cartoon characters. The cartoon format can make complex material, such as that found in chemistry curriculum, less intimidating and more accessible to students.

■ Computer Animations

Another method of instructional delivery used by Cepni & Şahin (2012) was computer animations. There are many advantages supporting the use of computer animations. Computer supported instruction does not only consider students’ alternative conceptions, but also helps students see the microscopic world via computer animations. It gives many opportunities to enrich the education environment. It facilitates the understanding of complex natural events more clearly. It provides students the possibility to see natural events which are not possible to bring into the classroom environment (Cepni & Şahin, 2012, p. 100). The use of computers in science classes also make it possible to do experiments that take a long time in the laboratory. Due to the more efficient use of time, students are able to repeat the experiments more than once to confirm results or account for errors in technique. In recent years computer animations and simulations in general, have gained momentum in teaching and learning the sciences. Nahum, Mamlok, Hofstein, & Taber (2010) cite “visualization, accessibility, and dynamicity” as some of the benefits of web-based learning. Finally, because a teacher can only help a small number of

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students in a laboratory environment at any given time, the computer's ability to give immediate feedback to each student makes it a valuable instrument of delivery.

Using Music to Foster Conceptual Change

Not only is music beneficial to aiding in short- and long-term information recall, but it can be a useful way to address and rectify student misconceptions. Careless & Douglass (2011) state "by thinking through music or songs, some [students] are able to access or unlock insights... that would not otherwise be readily available to them" (p. 450). Presenting misconceptions in familiar musical contexts can help students address and correct alternative conceptions, ultimately bringing about conceptual change.

Music has been used for thousands of years to tell stories and communicate information. One of the most fundamental goals of educators is to institute engaging methods of instruction, and using music as a means of communicating information to students is one such method. From a neuroscience perspective, listening to music activates a cognitive network of brain regions related to attention, semantic processing, memory, motor functions, and emotional processing. Peterson and Thaut (2007) state that "in addition to engaging cognitive and emotional networks, music listening... stimulates the healthy brain areas that normally show increased excitability and adaptability in the sub-acute recovery phase... and thereby enhance and speed up the spontaneous recovery process" (p. 219). In addition to faster recovery of information, music has been shown to be beneficial to the capacity of an individual's long- and short-term memory. Smolinski (2011) states "researchers have investigated the long- and short-term effects of song on memory and found that music aided in the recall of information" (p.42). The fact that music has been shown to improve memory recall makes it an intriguing option for educators looking

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for alternative ways to introduce a new topic or review previously covered content. In regards to the timing of the use of these songs, Last (2009) suggests that they are effectively used “to introduce a new topic in a novel manner, whereas in other cases... more appropriate to play the song after the students have the necessary background to appreciate the lyrics. An alternative approach is to use a song simply to provide students with a break from concentrating on the lecture topic and taking notes” (p. 1202). Music is not only helpful in assisting students with content and recall, but it is a fresh perspective that can be used to spark interest in material that they might not otherwise be engaged.

Relevant Theories

Metacognition

Metacognition is often interpreted as “thinking about your thinking” and involves both awareness and control of one’s cognitive processes (Seraphin, Philippoff, Kaupp, & Vallin, 2012, p. 368). The National Research Council defines metacognition as the process of reflecting on and directing one’s own thinking. Seraphin, Philippoff, Kaupp, & Vallin (2012) state that application of metacognitive skills requires knowledge of learning strategies and an awareness of when to appropriately apply each strategy. In addition to this awareness, or knowledge component, there is a control, or regulation component, which involves evaluating what you currently know and determining what you still need to learn (Seraphin, Philippoff, Kaupp, & Vallin, 2012, p. 368). Self-regulation and motivation, two factors that influence student learning, are tied to metacognition. Metacognition is closely related to learning regulation and has been implicated as a distinguishing factor of “expert students” (Seraphin, Philippoff, Kaupp, & Vallin, 2012, p. 368). Metacognition is also connected to student

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motivation. Students with developed metacognitive skills take ownership of their learning to be active learners. According to Seraphin, Philippoff, Kaupp, & Vallin (2012) considerable evidence has shown the positive impact of metacognition activity on student thinking and a positive correlation between metacognitive awareness and student learning. Metacognitive instruction also promotes scientific literacy by improving concept durability and the transfer of scientific knowledge from school to outside the classroom (Seraphin, Philippoff, Kaupp, & Vallin, 2012, p. 368). Warner-Dobrowski & Belisle (2012) suggest metacognition is developmental. By the time children are in preschool they have already begun to develop metacognitive skills such as using strategies, detecting errors, and articulating their thinking. A child's ability to direct, monitor, and reflect on his or her thinking develops rapidly during the elementary school years. By middle school, children are capable of identifying what they need to progress as learners, and of recognizing that they need to use a variety of problem-solving strategies to overcome learning challenges (Warner-Dobrowski & Belisle, 2012, p. 16). The implications of honing these problem-solving strategies can have a profound impact on a student's level of achievement in chemistry. Many of the test questions or homework problems students must answer require that students are able to process what information is given to them within the question itself, as well as, what information must be derived from the given information. In short, chemistry requires that students develop good problem-solving strategies and techniques in order to understand what the question is asking, in addition to how to arrive at the correct answer.

The 5E Instructional Model

Cepni & Şahin (2012) state although students' misconceptions cannot be remedied completely with the conceptual change approach; this approach is useful in reducing the effects of misconceptions and preventing new ones from arising. Cepni & Şahin (2012) examined the

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benefits of integrating the 5E Instructional Model in addressing misconceptions. The 5E Instructional Model is one of the constructivist learning approach models and is based on a composite of the experiential learning philosophies of Johann Herbart, John Dewey, J. Myron Atkin, and Robert Karplus. Studies clearly show that the 5E Instructional Model is highly appropriate for getting conceptual change in the teaching of science concepts (Cepni & Şahin, 2012, p. 98). The 5E Instructional Model is grounded in sound educational theory, has a growing base of research to support its effectiveness, and has had a significant impact on science education (Bybee et al., 2006, p. 12). The implications of implementing the 5E Instructional Model in a chemistry classroom are considerable. The fact that there is research validating its use, not only in the classroom, but more specifically in science classrooms, indicates the positive effect it has on student achievement.

The design of the 5E Instructional Model makes it especially effective for science educators. It utilizes engaging activities that can be structured so that students are able to explore, explain, extend, and evaluate their progress. According to Bybee et al. (2006) ideas are best introduced when students see a need or a reason for their use—this helps them see relevant uses of the knowledge to make sense of what they are learning. Cepni & Şahin (2012) discuss the five phases of the 5E instructional model:

- First Phase '**Engage**': It includes attracting students' interest to the concept, revealing students' pre-knowledge about the concept and making students aware of their own knowledge and querying them about the concept. At this stage, students are not expected to express the correct concept. This stage is a warm-up phase in which students become ready to learn.

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- Second Phase '**Explore**': Students test their own knowledge by doing observations and gaining experiences about the concept. They work in groups. They try to explore scientific knowledge. Teacher directs students to study with video, computer, and in library environments and students are encouraged to solve problems.
- Third Phase '**Explain**': This phase is the teachers' most active phase and it includes students sharing and debating their experiences with each other. Students are encouraged to compare their prior knowledge with observations and explain the relationship between them. At this stage, teachers could benefit from using methods such as computer software, flash animations, Conceptual Change Text (CCT), argumentation, expression, and video.
- Fourth Phase '**Elaborate**': Students are encouraged to adapt new knowledge they have acquired in previous phases to different situations and to associate it with their daily life. Work sheets, model preparation, activities including drawing, problem situations and questions related to daily life are used to enhance the relationship between the concept and daily life. Moreover, at this stage, students find answers to the questions which are asked to motivate them at the "enter" stage.
- Fifth Phase '**Evaluate**': Students query new knowledge of the concept they have learned in the previous four stages and make an extraction. And, eventually, they assess their own improvement.

Since students' misconceptions are not completely remedied by means of only one conceptual change method, using different conceptual change methods embedded in the 5E Instructional Model together will not only be more effective in enhancing students' conceptual understanding, but also it may eliminate most of students' misconceptions (Cepni & Şahin, 2012,

p. 98). Cepni & Şahin (2012) state that teacher and student guide materials should be developed and different teaching methods and techniques embedded in the 5E Instructional Model should be used. This suggests that there are no magic bullets in helping students correct their misconceptions. Instead, educators should consider attacking them using multiple methods, such as both conceptual change methods, in conjunction with the 5E Instructional Method.

Argumentation

Argumentation is a fundamental discourse of science, a part of the practice of science for developing, evaluating, and refining scientific theories about the natural world (Aydeniz, Pabuccu, Cetin, & Kaya, 2012, p.1303). Scientists argue over the questions they pose, the methods of investigations they use, the nature and source of evidence they use, and the conclusions they arrive at. Aydeniz, Pabuccu, Cetin, & Kaya (2012) state that argumentation enhances the quality of student learning because it engages students in the public exercise of reasoning. When learners are challenged to externalize their reasoning, they are more likely to notice the inconsistencies in their reasoning, and with the help of their peers and their teacher, they are better able to develop reasons that pass the test of rationality than if they were to learn science through traditional methods (i.e. listening to a teacher lecture). This is because argumentation engages students in dialogical reasoning and makes learning a social as well as a cognitive activity (Aydeniz, Pabuccu, Cetin, & Kaya, 2012, p.1304).

Celik & Kılıc (2014) state that argumentation activities are important to the process of improving conceptual understanding. There is a relationship between argumentation and conceptual change, and thus argumentation enhances conceptual understanding since an argument deals with disagreement, which is the first step of conceptual change (Celik & Kılıc, 2014, p. 58). Venville & Dawson (2010) state that the process of participating in and listening to

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rational and sophisticated arguments modeled and encouraged by the teacher may have positively impacted students' knowledge. Engagement in argument construction may have encouraged students to make meaningful "connections between isolated facts and concepts" and thus resulting in an improved understanding of the topics under investigation (Venville & Dawson, 2010, p. 970). Argumentation gives students a chance to consolidate and elaborate on their existing ideas. Additionally, Venville & Dawson (2010) state that students developed increased understanding because they were able to apply their knowledge to meaningful or practical contexts. Finally, the authors argue that the scaffolding of student thinking during argumentation may have contributed to the reported learning gains in students' conceptual understanding. These results suggest that when argumentation is used effectively, it can result in significant learning gains for students. Through participation in group activities that encourage debate and discourse, students are forced to connect common themes and put together cohesive arguments. This not only reinforces the content, but helps students make valuable connections and identify misconceptions.

Argumentation creates a context for the learners to elaborate on their pre-existing ideas in a social context and a chance for their peers to evaluate the rationality and accuracy of their ideas and provide feedback to the learners (Aydeniz, Pabuccu, Cetin, & Kaya, 2012, p.1317).

Argumentation, in general, and written argumentation particularly, engages students in reflective metacognitive thinking. When students develop written arguments, they have to organize the information they already know and communicate their knowledge to the teacher in the most convincing and coherent way possible (Aydeniz, Pabuccu, Cetin, & Kaya, 2012, p.1317). This type of reflective activity can help students become aware of gaps in their knowledge. Aydeniz, Pabuccu, Cetin, & Kaya (2012) go on to state that engaging students in verbal argumentation

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after they had developed their written arguments helped the students to address the gaps in their knowledge by listening to their peers' ideas and asking questions to clarify their understandings.

Aydeniz, Pabuccu, Cetin, & Kaya (2012) discuss the following implications for the role of argumentation in bringing about conceptual change in students' alternative conceptions. Recent research on conceptual change suggests the use of instructional strategies that can stimulate a restructuring of students' understanding of scientific concepts. These include strategies aiming to increase students' metacognitive awareness, fostering collaboration, and promoting dialogue among the students (Aydeniz, Pabuccu, Cetin, & Kaya, 2012, p.1318). The authors go on to state that such strategies result in higher levels of thinking, recognition of the gaps in one's knowledge, and articulation of the relationships between various variables associated with a particular science concept and thus increase the plausibility and intelligibility of scientifically correct ideas. These are the cognitive processes facilitated when students engage in argument construction and evaluation (Aydeniz, Pabuccu, Cetin, & Kaya, 2012, p.1318). Argumentation forces students to challenge their peers through questioning to substantiate their claims to knowledge. Questioning is a key inquiry practice that encourages elaboration, expansion, and interpretation and thus driving the students to a deeper understanding of the concepts under investigation. In addition, Aydeniz, Pabuccu, Cetin, & Kaya (2012) state that argumentation has been proven to enhance the quality of student learning as it engages students in epistemic thinking, increased abstraction of knowledge, and in-depth investigation of scientific ideas. It follows that argumentation may be one of the most effective tools for bringing about conceptual change in students' conceptual understanding of "hard to learn" science concepts (Aydeniz, Pabuccu, Cetin, & Kaya, 2012, p.1318). Argumentation requires that students collect and analyze data, make comparisons, and justify claims with evidence. This

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process is what makes argumentation a valuable tool in fostering conceptual change. Students are not just parroting back answers; instead, they must construct coherent arguments and justify them to their peers. When two perspectives differ, argumentation facilitates further discussion which reinforces knowledge in one student, and helps the other student properly scaffold knowledge.

Active Learning

Michael (2006) defines active learning as the process of having students engage in some activity that forces them to reflect upon ideas and how they are using those ideas... keeping students mentally, and often physically, active in their learning through activities that involve them in gathering information, thinking, and problem solving (Michael, 2006, p. 160). Murphy, Picione, & Holme (2010) state by actively engaging students in any activity (particularly when focused on the content of the course), the instructor can reinvigorate students and reengage the learning process. It requires students to regularly assess their own degree of understanding and skill at handling concepts or problems in a particular discipline through attaining knowledge by participating or contributing. Active learning is facilitated through “student-centered instruction”. Michael (2006) defines student-centered instruction [SCI] as an instructional approach in which students influence the content, activities, materials, and pace of learning. This learning model places the student (learner) in the center of the learning process. The instructor provides students with opportunities to learn independently and from one another and coaches them in the skills they need to do so effectively (Michael, 2006, p. 160). This is in contrast to traditional Behaviorist theories which made the teacher the center of attention, while students passively listen and take notes.

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The SCI approach includes such techniques as substituting active learning experiences for lectures, assigning open-ended problems and problems requiring critical or creative thinking that cannot be solved by following text examples, involving students in simulations and role plays, and using self-paced and/or cooperative (team-based) learning. Properly implemented SCI can lead to increased motivation to learn, greater retention of knowledge, deeper understanding, and more positive attitudes towards the subject being taught (Michael, 2006, p. 160).

Michael (2006) lists the following approaches to student-centered/active learning:

- Problem-based or case based learning
- Cooperative/collaborative learning/group work of all kinds
- Think-pair-share or peer instruction
- Conceptual change strategies
- Inquiry-based learning
- Discovery learning
- Technology-enhanced learning

Educational research in chemistry has focused quite strongly on uncovering the misconceptions that students of all educational levels (K–graduate school) bring to the chemistry classroom (Michael, 2006, p. 163). As the understanding of the prevalence and robustness of these misconceptions has been clarified, much attention has been turned to the efficacy of various teaching techniques to help students repair their faulty mental models (Michael, 2006, p. 163). Michael (2006) studied the effects of student-centered/active learning and reported that students believe that it significantly contributed to a greater understanding of the concepts of chemistry... greater conceptual understanding resulted from using a teaching approach that included student generated arguments/counterarguments than from conventional approaches. The author also notes that active learning does not happen by itself, it occurs in the classroom when the teacher creates a learning environment that makes it more likely to occur (Michael, 2006, p. 164). Student-centered/active learning incorporates many common themes encountered in trying

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to help students achieve conceptual change. SCI provides opportunities for collaborative learning, argumentation, and student engagement, exploration, explanation, elaboration, and evaluation (the 5 “E”s of the 5E Instructional Model). All of which are essential in the pursuit of exhuming and rectifying student misconceptions in chemistry.

Conclusion

There is no way to prevent students from forming misconceptions. They are generated out of a student’s experiences and prior knowledge. However, their prevalence among students must not be ignored. These alternative conceptions, false theories, and incorrect concepts need to be identified, addressed, and corrected. This is accomplished through conceptual change, which has been traditionally facilitated through the use of conceptual change texts and computer animations, and potentially through the incorporation of music. Teachers can foster conceptual change through engaging, exploring, explaining, elaborating, and evaluating students with the 5E Instructional Model. Conceptual change can be facilitated through student-centered/active learning experiences. In addition, getting students to self-reflect about their learning strategies (metacognition) can help motivate students to become more successful. Finally, argumentation and active learning can help students overcome misconceptions through externalizing their reasoning. When they do so, they are more likely to notice inconsistencies in their own reasoning.

If there is a positive aspect to this dilemma, it is that although it is common for students to have misconceptions... the actual misconceptions that arise in chemistry tend to be similar from student to student. The design of this thesis is to provide teachers an alternative method to address and overcome common misconceptions students have regarding chemistry. The research

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suggests the best way to accomplish this task is to address the misconception explicitly, provide evidence as to why the misconception is incorrect, and present students with the correct chemical concept. To help foster this conceptual change, the accompanying songbook was composed. It is a collection of 6 songs that many students will be familiar with musically. As such, the musical content chosen was kept in accordance with the original melodies, but new lyrical content was developed to help students confront and dispel their alternative conceptions.

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A
They have no mass
D
Cause I can't see them
A
Morgan is wrong
E
So I will tell you the truth
D A
Saying', "This my message to you"

[Chorus]

A A
Even though now, some can't be seen
D A
You know every little gas, is gonna have some mass
A A
Saying even though now, some can't be seen
D A
You know every little gas, gonna have some mass

[Verse 2]

A
So listen Morgan
E
Gas particles are so small
A
They take up space
D
And are made of atoms
A
Therefore a gas
E
Most certainly has some mass
D A
Sayin', "This is my message to you"

[Chorus]

A A
Even though now, some can't be seen

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D A
You know every little gas, is gonna have some mass
A A
Saying even though now, some can't be seen
D A
You know every little gas, gonna have some mass

[Verse 3]

A
So listen Morgan
E
Some gases can not be seen
A
But this is because
D
Particles are spread out
A
And "invisible"
E
Because they let light pass through
D A
Sayin', "This is my message to you"

[Chorus]

A A A
Even though now, some can't be seen
D A
You know every little gas, is gonna have some mass
A A
Saying even though now, some can't be seen
D A
You know every little gas, gonna have some mass

Goal: The goal of this song is to dispel the common chemistry misconception that gases have no mass. This is accomplished by first confronting the students with the alternative conception, providing them with chemical evidence as to why it is not valid, and reinforcing the correct concept through the repeated chorus.

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Practical Application: This song would be useful following a unit dealing with phases of matter. Once they have been exposed to the material and have a solid foundation of the characteristics of solids, liquids, and gases, this song would enhance their knowledge and underpin the correct chemical knowledge that all gases have mass.

Song #2 “Heat Does Not Only Rise”

(Modeled after “Bad Moon Rising” by Creedence Clearwater Revival)

Misconception Addressed: The misconception this song addresses is that some students believe that because “hot air” rises, that “heat” only rises.

Chords and Lyrics:

[Intro]

D A G D

[Verse 1]

D A G D
Pete says heat only rises
D A G D
Pete says raise your hand and see
D A G D
Pete says its warmer near the ceiling
D A G D
Pete asks do you agree with me?

[Chorus]

G
No Pete you will see
D
That heat is energy
A G D
And heat does not only rise

[Verse 2]

D A G D
Pete says I thought that hot air rises
D A G D
Well Pete I'll say that much is true

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D A G D

Hot air is less dense than cold air

D A G D

And what causes it to rise

[Chorus]

G

Now Pete you can see

D

That heat is energy

A G D

And heat does not only rise

[Verse 3]

D A G D

Now Pete, heat is not a substance

D A G D

Heat is energy transferred

D A G D

That means it travels all directions

D A G D

Not just up as you observed

[Chorus] X2

G

Now Pete you can see

D

That heat is energy

A G D

And heat does not only rise

Goal: The goal of this song is to dispel the common chemistry misconception that heat only rises. This is accomplished by first confronting the students with the alternative conception, providing them with chemical evidence as to why it is not valid, and reinforcing the correct concept through the repeated chorus.

Practical Application: This song would be useful following a unit dealing with thermodynamics. Once they have been exposed to the material and have a solid foundation of the

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content pertaining heat and energy, this song would enhance their knowledge and help solidify the distinction between “hot air” and “thermal energy”.

Song #3 “Bubbles That You See”

(Modeled after “Browned Eyed Girl” by Van Morrison)

Misconception Addressed: The misconception this song addresses is that some students believe because they can’t see anything inside of the bubbles observed when boiling water, that they are empty vessels.

Chords and Lyrics:

[Intro]

G C G D
G C G D

[Verse 1]

G C G D
Nothings in bubbles, I just heard Jane say
G C G D
I see they’re empty, when water is boiling
G C G D
Jane, what I’m about to tell you, may come as a surprise
G C G D C
Bubbles are the result of temperature rising to
D G Em C D G D7
Its boiling point, water’s boiling point

[Verse 2]

G C G D
Small amounts of air is dissolved and so
G C G D
As temperature rises, their solubility gets low
G C G D
Small amounts of carbon dioxide, nitrogen, and oxygen
G C G D C
Form the first bubbles you see as water starts boiling
D G Em C D G
At its boiling point, water’s boiling point

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Practical Application: This song would be useful following a unit dealing with phases of matter, phase change (evaporation), or the heating curve of water. Once they have been exposed to the material and have a solid foundation of the concept of evaporation, this song would enhance their knowledge and underpin the correct chemical knowledge that all bubbles observed when boiling water have either air (as water temperature increases towards its boiling point) or water vapor (during actual boiling).

Song #4 “Equations Balanced”

(Modeled after “Spirit in the Sky” by Norman Greenbaum)

Misconception Addressed: The misconception this song addresses is that some students believe as long as the same elements are present on both sides of a chemical equation, that it is considered balanced.

Chords and Lyrics:

[Verse 1]

A
Dave thinks equations balance
D
When both sides same elements exist
A
If the same elements reside
E A
Then a balanced equation is identified

[Chorus]

A
Listen up Dave, there is more to balancing
D
It has to do with atom counting
A
The number seen on the left side
E A
Is the same number that we need on the right

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[Verse 2]

A
The elements must be the same
D
But so must the number we claim
A
So you know it is balanced
E A
Both sides of the arrow same number of them exist

[Chorus]

A
Listen up Dave, there is more to balancing
D
It has to do with atom counting
A
The number seen on the left side
E A
Is the same number that we need on the right

[Verse 3]

A
As I told him, Dave flashed a grin
D
I know I've got to count the atoms
A
Now I know that on both sides
E A
The number on the left equals the number on the right

[Chorus]

A
Listen up Dave, there is more to balancing
D
It has to do with atom counting
A
The number seen on the left side
E A
Is the same number that we need on the right

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Goal: The goal of this song is to dispel the common chemistry misconception that equations are balanced by simply having the same elements present as reactants and products. This is accomplished by first confronting the students with the alternative conception, providing them with chemical evidence as to why it is not valid, and reinforcing the correct concept through the repeated chorus.

Practical Application: This song would be useful following a unit dealing with chemical reactions and balancing chemical equations. Once they have been exposed to the material and have a solid foundation of the various types of chemical equations, this song would enhance their knowledge and confirm that the quantity of atoms of every element present in the reaction equation must be equal on both sides of the arrow.

Song #5 “Hydrogen Bonding”

(Modeled after “Hooked on a Feeling” by Blue Swede)

Misconception Addressed: The misconception this song addresses is that some students believe that any bond containing the element hydrogen qualifies it as a “hydrogen bond”.

Chords and Lyrics:

Original recording first verse is performed a capella. I added the chords depending on preference.

Capo 1st fret

[Intro]

Ooga Chuka Ooga Ooga Chuka Ooga Ooga Ooga Chuka

Ooga Ooga Ooga Chuka Ooga Ooga Ooga Chuka ..

[Verse 1]

G D G7 C
Kate can't stop this feeling that Hydrogen Bonding
Cm G D D7

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Takes place between Hydrogen and anything

D7 G B7

As long as the compound contains Hydrogen

B7 Em G7

Then the bond type must be the same

[Chorus]

C D G D

But Hy-y-y-y drogen bonding

D C

Happens only between

D G Bm C D

Hydrogen and N, O, or Fluorine

[Verse 2]

G D G7 C

Electronegativity creates polarity

Cm G D D7

So molecules end with regions where charge is seen

G D G7 C

Positive attracts to negative for sure

Cm G D D7

And molecules line up so this can endure

G B7

The positive end with the Hydrogen

B7 Em G7

Is attracted to the other's negative region

[Chorus]

C D G D

But Hy-y-y-y drogen bonding

D C

Happens only between

D G Bm C D

Hydrogen and N, O, or Fluorine

[Interlude]

G D G7 C Cm

G B7

The positive end with the Hydrogen

B7 Em G7

Is attracted to the other's negative region

[Chorus]

C D G D

But Hy-y-y-y drogen bonding

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D C
Happens only between
D G Bm C D
Hydrogen and N, O, or Fluorine

[Outro]

C D G D
That Hydrogen bonding
D C
Happens only between
D G Bm C D
Hydrogen and N, O, or Fluorine
C D G D
But Hy-y-y drogen bonding
D C
Happens only between
D G Bm C D
Hydrogen and N, O, or Fluorine (Fades out)

Goal: The goal of this song is to dispel the common chemistry misconception that a bond between any other chemical entity and hydrogen qualifies it as a hydrogen bond. This is accomplished by first confronting the students with the alternative conception, providing them with chemical evidence as to why it is not valid, and reinforcing the correct concept through the repeated chorus.

Practical Application: This song would be useful following a unit dealing with types of chemical bonds. Once they have been exposed to the material and have a solid foundation of the different types of bonds, this song would enhance their knowledge and confirm that hydrogen bonding occurs between the hydrogen of one molecule and the nitrogen, oxygen, or fluorine of another molecule.

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Song #6 “Why Things Float on Water”

Modeled after “Oooh Child” by The Five Stairsteps

Misconception Addressed: The misconception this song addresses is that some students believe things float on water because they are lighter than water.

Chords and Lyrics:

[Intro:]

C G F C G
C G F C G

[Verse 1]

C G C G
Ooh-oo Kyle, Sara said things float on water
C G Am
Ooh-oo Kyle, because they are lighter
C G C G
Ooh-oo Kyle, Sara said things float on water
C G Am
Ooh-oo Kyle, because they are lighter

[Chorus]

D A D A
I say things float when they are less dense than water
D A G
But sink when their density is greater
D A D A
I say things don't sink because they are heavier than water
D A G
Or because they are lighter

[Verse 2]

C G C G
Ooh-oo Kyle, density is how much matter
C G Am
Ooh-oo Kyle, per units of volume
C G C G
Ooh-oo Kyle, now you know that things float on water
C G Am
Ooh-oo Kyle, not because they are lighter

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[Chorus]

D A D A
I say things float when they are less dense than water
D A G
But sink when their density is greater
D A D A
I say things don't sink because they are heavier than water
D A G
Or because they are lighter

[Verse 3]

C G C G
Ooh-oo Kyle, Sara said things float on water
C G Am
Ooh-oo Kyle, because they are lighter
C G C G
Ooh-oo Kyle, now you know that things float on water
C G Am
Ooh-oo Kyle, not because they are lighter

[Chorus] X2

D A D A
I say things float when they are less dense than water
D A G
But sink when their density is greater
D A D A
I say things don't sink because they are heavier than water
D A G
Or because they are lighter

D A D A
I say things float when they are less dense than water
D A G
But sink when their density is greater
D A D A
I say things don't sink because they are heavier than water
D A G
Or because they are lighter

Goal: The goal of this song is to dispel the common chemistry misconception that things float on water because they are lighter than water. This accomplished by first confronting the

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students with the alternative conception, providing them with chemical evidence as to why it is not valid, and reinforcing the correct concept through the repeated chorus.

Practical Application: This song would be useful following a unit dealing with the density of matter. Once they have been exposed to the material and have a solid foundation of the concept of density, this song would enhance their knowledge and confirm that things float or sink based on a comparison of the representative densities of both things in question.

Chapter Four: Discussion

Chemistry is bountiful with abstract concepts and content-specific vocabulary. This creates a host of opportunities for students to construct incorrect assumptions to make sense of material they don't entirely understand. These student misconceptions are a significant barrier to scaffolding of proper knowledge and prevent them from deeper understanding. The danger for teachers and students alike is that misconceptions are common, and need to be exhumed. Until they are explicitly confronted, the student accepts these alternative conceptions as factual. In an effort to engage students in content, exhume dormant falsehoods, and dispel misconceptions, a novel use of music has been investigated. The goal of this songbook is to facilitate conceptual change in a manner that benefits both teachers and students.

Using music and song to address and dispel misconceptions urges students to adopt a metacognitive approach to their own learning. Thinking about how they think, and how they learn, has been shown to improve scientific literacy and overall academic achievement. The key elements of the 5E Instructional Model are for teachers to engage, explore, explain, extend, and evaluate. Using music, such as the songs presented in this thesis, touches on aspects of all five elements. It engages the students through novel use of music, forces them to explore the presented material, explains the correct chemical concepts, extends student knowledge through dispelling the misconception, and helps teachers and students evaluate the level of deeper understanding following the learning process. Argumentation challenges students through questioning and encourages elaboration, expansion, and interpretation... ultimately advancing deeper understanding of the concepts under investigation. Finally, active learning (student-centered instruction) stimulates student engagement through activities that force them to reflect upon ideas and how they are using those ideas. One such approach would be to provide students

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the opportunity to complete an alternative assessment that has them create/perform their own song.

Music has not been extensively used in the sciences as an approach to instruction. However, research has shown that music is a valuable tool in improving short- and long-term information retention, in addition to speed of information recall. The presence of familiar melody promotes connections in our neural network that traditional methods of instruction does not. Opportunities for future research into other mechanisms that utilize music in science instruction are promising and should be investigated further.

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Appendix

The following scribbles and ramblings represent a small subset of the napkins, post it notes, and scrap pieces of paper that I used during the creative process.

TUNE: THREE LITTLE BIRDS

GASES HAVE MASS
EVEN ^{THOUGH} ~~TOLD ME~~ SOME CAN'T BE SEEN
ME SOME THING

DON'T WORRY ABOUT A THING
~~BECAUSE~~ YOU KNOW EVERY LITTLE GAS GONNA HAVE SOME MASS
BECAUSE EVERY LITTLE THING GONNA BE ALL RIGHT
SAYING EVEN THOUGH SOME CAN'T SEEN
SINGING DON'T WORRY ABOUT A THING
I EVERY LITTLE GAS GONNA HAVE SOME MASS
CAUSE EVERY LITTLE THING GONNA BE ALL RIGHT

A ^{STATE} ~~MADE UP~~ OF MATTER JUST TALKED TO MORGAN
ROSE UP THIS MORNING
WHO ^{MEANS} SAID THEY DON'T HAVE MASS
SMILED AT THE RISING SUN
~~SHE~~ ~~TALKS~~
3 LITTLE BIRDS THEY DON'T HAVE MASS

PICH BY MY DOORSTEP BECAUSE I CAN'T SEE THEM
SINGIN' SWEET SONGS INVISIBLE
OF MELODIES ³ PURE AND TRUE
MUST MEAN THAT THEY DON'T HAVE MASS
SAYING THIS IS MY MESSAGE TO YOU

VERSE 1 "Heat does not only rise"

(Pete) ~~Paul~~ Says heat only rises

(Pete) Paul says raise your hand and see

(Pete) Paul says its warmer near the ceiling

(Pete) Paul says do you agree with me.

CHORUS (Pete) ~~that heat is energy~~

NO ~~Paul~~ You will see why i disagree

~~that~~ That heat is energy

And heat ^{does not only rise} ~~heat is energy~~

Verse 2 (Pete)

Paul says I thought that hot air rises

well (Pete) Paul I say that much is true

Hot air ^(is less dense than) ~~travels toward~~ the cold air

~~we should discuss air currents too~~

And what causes it to rise

Chorus

(Pete)
I hope ~~fast~~ you will see
Heat is energy
And heat does not only rise

Verse 3

Heat ~~travels~~ ^(Pete) on
Now ~~fast~~, Heat is not a substance
Heat is energy transferred
That means it travels all directions
Not just "up" as you observed.

Chorus

(Pete)
Now ~~fast~~ you can see
Heat is energy
And heat does not only rise

↻ [x 2 ?]

The air we breathe is different from the element oxygen
Scienceline.ucsb.edu What causes bubbles to form when boiling water?

Asks in the ~~what's~~ bubbles? I ~~hear~~ just heard Jane say
When I'm in boiling water, is oxygen bubbles start rising?
~~Maybe its~~ ~~air~~ maybe its
~~inside them~~ I'm not sure what's in them is nothing & c

~~For sure I~~
What's ~~in~~ in the bubbles, I just heard Jane say
When I'm boiling water, is oxygen rising?

Maybe what's in them is nothing, Jane isn't quite sure
~~the~~ ^{one} of her statements is ~~right~~ correct, ~~no other two~~
but there is more

What it is that we
all breathe in ...

Not just oxygen

As ~~the~~ it achieves boiling point | liquid ^{converts to gas} turns to vapor
the water vapor ~~forms~~ collects and ~~forms~~ bubbles that ~~are~~ the other kind of
So there's two types of bubbles → That's the bubbles that form
well Jane it is something inside the bubbles that you see
at its boiling point at water's boiling point

Nothing's in Bubbles. I just heard Jane say
I see that they're empty when water is boiling.
Jane ^{what} I'm about to tell you ^{may come as a surprise} ~~there's two types of bubbles~~
~~one~~ ~~when the temperature rises.~~ The other
Bubbles are the result of temperature rising to
its boiling point water's boiling point

~~Water~~ ~~has~~ ~~gases~~ dissolved
Small amounts of gas are dissolved in ^{water} ~~water~~
As temperature rises their solubility gets low
Small amounts of carbon dioxide, nitrogen, and oxygen
~~are in the bubbles~~
Form the first bubbles we see | as water starts boiling
at its boiling point water's boiling point

Will you remember those clues I sing
As water temperature rises gases are evolved
~~Bubbles in boiling water are~~
~~As water temperature rises~~
Water vapor, carbon dioxide, in mystery solved
These bubbles are first to show up half the mystery solved
As water temperature rises gases are evolved
These bubbles are first to show up half the mystery
solved

Rectifying Common Chemistry Misconceptions Through Music

[Verse]

G C G D
So hard to find my way, now that I'm all on my own
G C G D
I saw you just the other day, my, you have grown
G C G D
Cast my memory back there, Lord, sometimes I'm overcome thinkin' a
bout
G C G D C
Makin' love in the green grass, behind the stadium with you
D G Em C D G
My brown-eyed girl, a-you're my brown-eyed girl

[Chorus]

b7 G
Do you remember when we used to sing
C G D
Sha la la la la la la la la la la te da
G C G D
Sha la la la la la la la la la la te da
G C G D
Sha la la la la la la la la la la te da
G C G D
Sha la la la la la la la la la la te da

Will you remember These clues I sing
As water temperature rises gases are evolved
These bubbles are first to show up half the mystery solved
~~As water approaches~~ →
Next liquid converts to gas as it gets to boiling point's
Water vapor bubbles the other ^{type of bubbles} bubbles that we
This vapor ~~collects and~~ forms bubbles that we see
you

Rectifying Common Chemistry Misconceptions Through Music

SPIRIT IN THE SKY by: Norman Greenbaum

[Verse]

A
When I die and they lay me to rest,
D
Gonna go to the place that's best.
A
When they lay me down to die,
E
Goin on up to the spirit in the sky.

Dave Thinks equations are balanced
When both sides same elements exist
When ~~the~~ same elements reside
Then ↓ balanced equations ~~are~~ identified
A IS

[Chorus]

A
Goin on up to the spirit in the sky.
D
That's where I'm gonna go, when I die.
A
When I die and they lay me to rest,
E
I'm gonna go to the place that's the best.

Listen up Dave There is more to balancing
It has to do with ~~the~~ number of atoms
The number ~~we have~~ we ~~bring~~ counting
is the same number ~~we~~ ~~have~~ on the left side
that we need ~~represent~~ ~~on~~ the right

[Verse 2]

A
Prepare yourself, you know it's a must.
D
Gotta have a friend in Jesus.
A
So you know that when you die,
E
It's gonna recommend you to the spirit in the sky.

The elements must be the same
But so must The number we claim
So you know ~~the~~ balanced
it is
Both sides of the arrow the same
number of them exist

[Chorus]

A
Goin on up to the spirit in the sky.
D
That's where I'm gonna go, when I die.
A
When I die and they lay me to rest,
E
I'm gonna go to the place that's the best.

Repeat

[Verse 3]

A
Never been a sinner, I've never sinned.
D
I've got a friend in Jesus.
A
So you know that when I die,
E
It's gonna set me up with the spirit in the sky.

(I know) AS I told him, Dave flashed a grin
I've got to count the atoms
So I know that on both sides
The number on the left ~~equals~~
equals The number on the right

[Chorus]

CHORUS
REPEAT

Rectifying Common Chemistry Misconceptions Through Music

When we breathe ^{and} our lungs take it in
What we inhale is air and oxygen
Air and oxygen are the same gas

Kelly tells Jen what we breathe in
We inhale air and oxygen
When ~~breath~~ are ~~they~~ ~~empty~~,

Rectifying Common Chemistry Misconceptions Through Music

[Intro]

Ooga Chuka Ooga Ooga Ooga Chuka Ooga Ooga Ooga Chuka

Ooga Ooga Ooga Chuka Ooga Ooga Ooga Chuka ..

[Verse 1]

(A cappella + Ooga Chuka thru first verse. I added the chords.)

G D G7 C
I can't stop this feeling, deep inside of me.
Cm G D D7
Girl, you just don't realize, what you do to me.
D7 G B7
When you hold me, in your arms so tight,
B7 Em G7
You let me know, everything's alright..

thus
Kate ~~is not agreeing~~ ^{can't stop feeling} that Hydrogen Bonding
Takes place between Hydrogen and anything
As long as the compound has Hydrogen
Then the bond type must be the same

[Chorus]

C D G D
I-I-I-I I'm hooked on a feeling,
D C
I'm high on believing,
D G Em C D
That you're in love with m...e.

Hy - y - y - y
But ~~Hydrogen~~ Hydrogen Bonding
is when we are seeing
H with N, O, or Fluorine

[Verse 2]

G D G7 C
Lips as sweet as candy, its taste is on my mind.
Cm G D D7
Girl, you got me thirsty for another cup of wine.
G D G7 C
got a bug from you, girl, but I don't need no cure,
Cm G D D7
I just stay a victim, if I can for sure.
G B7
All the good love, when we're all alone,
B7 Em G7
Keep it up girl, yeah you turn me on.

Electronegativity creates polarity
So, molecules ~~have spots~~ end up with regions where charge is seen
Positive attracts to negative for sure
So Molecules line up so this can end up
The positive end with the Hydrogen

Rectifying Common Chemistry Misconceptions Through Music

[Interlude]

G D G7 C Cm

[Verse]

All the good love, when we're all alone,
Keep it up girl, yeah you turn me on.

The positive end with the Hydrogen
is attracted to another's negative
region

[Chorus]

I-I-I-I I'm hooked on a feeling,
I'm high on believing,
That you're in love with m...e.

Repeat Chorus
x 2

[Outro]

I'm hooked on a feeling and I'm high on
believing, that you're in love with me.
I said..I'm hooked on a feeling and I'm
high on believing, that you're in love with me.. (Fade.)

Rectifying Common Chemistry Misconceptions Through Music

Anthony Raymond
EDI 793 Songbook #6

[Intro:] C G F C G intro you should get an idea of timing - I've
C G F C tried to space the chords to match the song)

C G C G
Ooh-oo child, Things are gonna get easier
C G Am
Ooh-oo child, Things'll get brighter
C G C G
Ooh-oo child, Things are gonna get easier
C G Am
Ooh-oo child, Things'll get brighter

D A D
Some day, yeah We'll get it together and we'll get it all done
D A G
Some day, When your head is much lighter
D A D A
Some day, yeah We'll walk in the rays of a beautiful sun
D A G
Some day, When the world is much brighter

C G C G
Ooh-oo child, Things are gonna be easier
C G Am
Ooh-oo child, Things'll be brighter
C G C G
Ooh-oo child, Things are gonna be easier
C G Am
Ooh-oo child, Things'll be brighter

D A D A
Some day, yeah We'll get it together and we'll get it all done
D A G
Some day, When your head is much lighter
D A D A
Some day, yeah We'll walk in the rays of a beautiful sun
D A G
Some day, When the world is much brighter

(Next section play same as "ooh child" section)

Ooh-oo Kyle, Sara said on
Things ~~are gonna~~ float in water
Ooh-oo Kyle, because they are lighter
Ooh-oo Kyle, Sara said things float on
water
Ooh-oo Kyle, because they are lighter
I say things float when they
are less than water
~~Not because they are lighter~~
But sink when density's
greater
I say things don't sink because ~~objects~~ are
heavier than water.
for because they are
lighter

Chorus