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A Comparison of Lecture and Interactive Lecture Using Student Response Systems in an Inclusive and Non-Inclusive Classroom

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A COMPARISON OF LECTURE AND INTERACTIVE LECTURE USING STUDENT RESPONSE SYSTEMS IN AN INCLUSIVE AND NON-INCLUSIVE CLASSROOM

by

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DEDICATION

This dissertation is dedicated to my wonderful parents who have faithfully supported me throughout all of my life's endeavors. I want to thank them for their unwavering love and constant devotion during this process. Also, I want to thank all of my friends and family for their patience and compassionate support.

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ABSTRACT

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It is crucial for the most effective evidence-based educational practices to be identified and implemented in our classrooms, so that students can reach their academic potential. Active learning is not a new pedagogy, but many gaps still exist in the literature specifically concerning the technology of student response systems. In an attempt to address these shortcomings, this study compared the effects of the traditional lecture method verses lectures that incorporated student response systems on students' academic achievement immediately following the lecture. This study also examined the relation between student response systems and students with disabilities in an inclusive classroom. The instructional methods lecture and lecture plus student response systems were both effective in increasing student performance in a non-inclusive classroom and in an inclusive classroom. The student reponse system intervention was more effective than the lecture intervention in increasing students academic performance in the non-inclusive classroom. The lecture intervention was more effective than the student response intervention in increasing students' academic achievement in the inclusive class setting. The participating students with disabilities showed improvement during the lecture condition as well as in the lecture plus student response system condition, thus it remains unclear which instructional method (lecture or SRS) was most effective for students with disabilities.

Keywords: student response system, active learning, inclusion

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CHAPTER 1: Introduction

The relation between learning and technology has evolved significantly over the last several decades. This evolution has led to potential alterations in the pedagogy used to teach our youth. In 1996, the presidential nominee Bill Clinton stated, "I want to build a bridge into the 21^{st} century in which we expand opportunity through education, where computers are as much a part of the classroom as blackboards" (Kent & McNergney, 1999, p. 15). Today, technology used by classrooms may include computers as well as the following: educational software, class websites, blogs, interactive white boards, personal computer tablets, electronic books, electronic textbooks, podcasts, World Wide Web, and student response systems. In fact according to Compass Intelligence (2010), a global marketing and research company, government spending for educational technology is growing abundantly. In 2008, 46.5 billion dollars were allocated for educational technology while the estimate for 2012 is 56 billion dollars.

Even with the allocation of substantial government funding for technology in the classroom, the United States is falling farther and farther behind other industrialized nations concerning students' level of academic achievement. This decline has led to an increased political focus on assessment and accountability of both students and teachers in the school systems across the nation. Several initiatives have sought to aid teachers in elementary and secondary education to identify novel methods of instruction to help improve students' academic achievement (Pennuel, Boscardin, Masyn, & Crawford, 2007). The No Child Left Behind Act (NCLB) that was adopted in 2001 is an example of one of those initiatives. The main goal of NCLB is to help students reach an expected standard, which in return should improve the overall educational system. The NCLB Act was written to identify underperforming schools based on the results of frequently administered tests and progress monitoring. The NCLB requires any school that desires to receive federal money for education to introduce annual testing. The purpose of this annual testing is to help each individual student and teacher by identifying strengths and weaknesses in both learning and instruction.

Since assessment and accountability are now a central focus of the NCLB, formative assessments have become a method to evaluate the effectiveness of schools and its teachers based on student achievement. Formative assessments are conducted throughout the learning process to provide immediate feedback to the teachers and students to improve student achievement. Formative assessments are a pro-active approach to education due to the immediate information received by the teacher concerning the students' mastery of the subject at hand. The information received by the teacher can be used to identify struggling students and adjust his/her teaching methods accordingly. These assessments also aid in setting guidelines for the teacher's accountability. Each year educators are accountable for lessening the achievement gap, utilizing evidence-based interventions, including individuals with disabilities, meeting yearly standards and implementing teaching strategies supported by current pedagogical research.

Focusing on the utilization of technology in the classroom specifically technology that can assist teachers conduct formative assessments is critical due to the current position of the United States' educational system and the prevalence of technology in today's society. Students particularly have become accustomed to using technology in the majority of their daily lives, which includes the classroom (Caruso, 2004). Students have become more technology savvy and more comfortable with multi-tasking, and seem to desire constant e-communication (Skiba & Barton, 2006). The results of a study conducted by Wallis, Cole, Steptoe, and Dale (2006) found that 25%-35% of students surveyed said they simultaneously instant message, listen to music, operate the computer, or even read, while watching television. Based on the previous findings, it is not surprising that many students prefer technology in the classroom (Caruso, 2004). However, this relation between students and technology may make students less tolerant of passive learning environments, so a more active approach to learning may be needed (Murphy & Smark, 2006). If students are seeking a more active approach to learning, technology may be a potential way to meet this need.

It is now the job of the educators to determine if technology is more than just an enjoyable addition to the classroom. Considering the idea that students have been successfully learning without electronic technology for centuries, it is imperative for the education system to decipher if the benefits of technology in the classroom are worth the substantial financial cost of its addition. However, according to the U.S. Department of Education, both teachers and students would benefit from an assessment tool such as student response systems that enables formative assessments or feedback to be provided at various points during the learning process (Siew, 2003). Electronic student response system technology has the potential to meet this need by helping to evaluate and improve student performance, assess and advance teacher performance, and provide a technology that supports immediate feedback to the student and the teacher on throughout the learning process.

In conclusion, technology is a tool available to improve education. Nevertheless, it is vital for the educational system to adopt ways to measure student learning and the effectiveness of the teachers' instructional strategies when using this technology. This will help make strong practices and successful educators (Greer & McDonough, 1999). Specifically, the implementation of student response system technology could potentially improve learning for all students by advancing instructional methods. Finally, it is essential that teachers and students be provided with the most effective technology to make learning in all classrooms the most effective it can be.

CHAPTER 2: Literature Review

The purpose of this chapter is to examine and review the literature for two instructional paradigms: passive learning and active learning in both the non-inclusive and inclusive classroom. Next, this review will describe specific examples of instructional strategies based on each philosophy. Lecture is the passive learning approach addressed in this review. The active learning pedagogy examples discussed in this assessment include: guided notes, choral responding, response cards, and electronic student response systems.

Passive Learning

Passive learning is a teacher-centered approach to learning in which the students passively receive information from the teacher (Michel, Cater, & Varela, 2009). This approach to learning is based on the notion that students can learn by a mere transfer of information from teacher to student (Boyer, 1990). This school of thought views the teacher as the expert, and it is his or her role to communicate his or her knowledge to an audience of learners (Byrnes & Etter, 2008). In other words, the accountability for the students' learning is placed solely on the teacher. Passive learning facilitates learning by using covert behavior meaning that it is not an immediately observable behavior. Due to learning occurring by unobservable behavior, the teacher is unable to make formative assessment during instruction to determine the students' comprehension of the material being presented. The primary example of passive learning is lecture, which is described in detail below.

Lecture. The term lecture is of Latin origin meaning "to read out loud" (Mande, 2001). Lectures have been the most common method of instruction since ancient times (Brown & Atkins, 1988). This method of teaching is typically composed of reading text aloud followed by further explanation from the lecturer. During a lecture, the instructor is the primary source that conveys the information being presented. According to Bligh (1998) lectures are the most common method of instruction.

The two main components of lecture are content and delivery. Teaching via lectures is often accompanied by visual aids. These aids have included chalkboards, 35 mm slides, overhead projectors with transparencies, and most recently electronic presentations such as PowerPoint®. A study conducted by Seth, Upadhyaya, Ahmad and Kumar (2010) to determine teachers' preference for lecture delivery method revealed the majority of the educators sampled preferred the use of a chalkboard (40.47%). PowerPoint® presentations ranked second (31.1%) and transparencies with an overhead projector were the least preferred method of delivery (28.43%).

There are several positive aspects to the lecture method of teaching. First, lectures allow for the presentation of information, data and ideas in a brief manner (Mande, 2001). Second, this strategy is flexible because it can accommodate small groups but also permits a sizeable number of pupils to be instructed at one time (Lake, 2001). Third, when using the traditional lecture approach, the lecturer becomes the sole source of information, which increases the control of the specific material that is taught in the classroom (Sullivan & McIntosh, 1996). Also, both students and teachers are accustomed to lecture approach because it is the most common method of instruction

(Brown & Atkins, 1988). Finally, updating lectures to include the most recent relevant findings for the instructor is typically a relatively simple task (Hake, 1998)

One of the difficulties with the traditional lecture approach is student retention decreases dramatically after approximately 10 minutes (Thomas, 1972). A study conducted by Hartley and Davies (1978) found students remembered 70% of the information presented within the first 10 minutes of a lecture when immediately given a posttest. The same researchers found that the amount of information retained for the last 10 minutes of a lecture decreased to a mere 20%. Another limitation of lecturing as a strategic approach to teaching is that the personality of the presenter plays a role in the engagement of the audience (Wyckoff, 1973). It may also be difficult for the instructor to gauge the audience feedback for immediate comprehension especially in a large lecture hall setting (Duncan, 2005). Although clarification may be given during a lecture if requested in most cases, the lecture method does not promote student teacher interactions (Lake, 2001). Due to the lack of interaction, lectures have been found to be less effective than strategies such as active learning or one to one training (Bloom, 1984). Finally, as mentioned above, although the presenter's personality may be an advantage in maintaining the students' attention, it may also be a distraction from the learning material (Wyckoff, 1973). In contrast to the passive learning paradigm is the active approach to learning, which is defined and described in the next section.

Active Learning

Active learning is considered a behavioral approach to education. In the 1950s, B.F. Skinner first discussed behavioral approaches for learning in the classroom in an attempt to remedy several of the disadvantages associated with the traditional lecture method (Saville, Zinn, Neef, Norman & Ferreri, 2006). Direct instruction, precision teaching (Lindsley, 1996), programmed learning (Skinner, 1968), personalized systems of instruction (Keller & Sherman 1982) and active student responding (Heward, 1989) are examples of behavioral strategies for both teaching and learning within the classroom. Active learning focuses not only on the instructor's role in learning but it also focuses on the individual student's responsibility in learning (Bonwell & Eison, 1991). By focusing not only on the teacher's responsibility in learning but also on the student's role, accountability is shared between the teacher and the student.

The active learning approach to instruction is often implemented by utilizing active student responding (ASR). According to Barbetta, Heron, and Heward (1993), "active student responses (ASR) can be defined as an observable student response made to an instructional antecedent (e.g. responding verbally to a question, writing a response to a math problem, reading aloud)" (p. 111). Active student responding is in stark contrast to traditional methods of teaching such as lecture. Learning via lecture has often been viewed as a spectator sport for many decades (Chickering & Gamson, 1987). In other words, the teacher merely had to keep the students' attention and encourage passive listening for learning to occur. In comparison, active learning methods involve students not only listening, but also participating in learning specifically by requiring an overt response from the learner. By incorporating ASR, the learning environment becomes interactive and engaging.

ASR is an instructional pedagogy that allows the teacher to make formative assessments during instruction. Also, ASR as a teaching style offers increased opportunities for each student to respond throughout the instruction. Studies have shown a higher frequency of active student responding or opportunities to respond is functionally related to achievement success (Barbetta et al. 1993, Narayan, Heward, Gardner, Courson, & Omness, 1990). Active learning incorporates strategies that can easily be embedded into the traditional lecture method of teaching in the classroom environment (Heward et al., 1996). There is a large body of literature that supports active approaches to learning versus passive approaches to learning (Butler, Phillmann, & Smart, 2001; Yoder & Hochevar, 2005). There are many different topographies of active student responding such as guided notes, choral responding, response cards, and student response systems, which are described in detail in the next section.

Guided notes. Teacher created handouts that accompany a lecture, and require the learner to write or type in correct responses following standard cues are called guided notes (Heward et al., 1996). An advantage of guided notes is that the handouts can be tailored to fit each individual student's needs. In other words, all students will experience the same lecture, but the active responding could vary depending on the needs of the student. Lazarus (1991) examined the effectiveness of guided notes in a classroom. All 10 of the participants in his study were diagnosed with a learning disability. The results yielded improvements in quiz scores following the use of guided notes in all 10 of the study participants. Neef, McCord, and Ferreri (2006) compared the use of guided notes versus completed notes during a college lecture. The researchers found that guided notes were correlated with fewer errors on complex quiz questions. Guided notes are an example of an active approach to learning strategy that has been proven effective for both students without disabilities and students with disabilities.

Choral responding. Another form of active learning for the classroom is choral responding. Choral responding is a teaching strategy that permits learners to respond out loud and in unison to a teacher directed question (Heward, Courson, & Narayan, 1989). Kamps, Dugan, Leonard, & Daoust (1994) conducted a study with elementary aged students diagnosed with autism and developmental disabilities that found that the implementation of choral responding leads to increased student responding and active engagement. There are several other studies that support the use of choral responding (Wolery, Ault, Doyle, Gast & Griffen, 1992; Kamps et al., 1994).

Response cards. A response card is merely a card that can be held up concurrently by all students to indicate their answer to a question proposed by the teacher (Narayan et al., 1990). Davis and O'Neill (2004) performed a study comparing response cards to hand raising in a middle school resource classroom. The participants for this study were students diagnosed with a learning disability as well as students for whom English was a second language. The results revealed response cards increased the students' rate and accuracy of academic responding. Also, during the response card condition, an increase in weekly quiz scores was revealed.

Gardner, Heward, and Grossi (1994) conducted a study with 22 students in a fifth grade inner city classroom comparing the traditional hand-raising approach to response card implementation. The results of this study showed that all students scored higher on next day and 2-week follow up quizzes after participating in the response card intervention. There are many other studies that have shown similar positive results for response cards (Marmolejo, Wilder, & Bradley, 2004; Munro & Stephenson, 2009; Narayan et al., 1990).

Although guided notes, choral responding, and response cards are effective low tech teaching strategies, they are becoming obsolete given that students prefer more high tech or technologically advanced approaches to learning (Caruso, 2004). Electronic student response systems, such as clickers, are a technologically advanced active approach to learning, which like the above mentioned instructional methods also offer a high frequency of student response opportunities. In the following section, electronic student response systems are explained in great detail.

Electronic student response systems. For centuries students have learned by actively doing (Blackwell & McLaughlin, 2005). Therefore if the opportunity to perform a particular skill increases, an increase in learning related to that skill should occur. A theoretical view offered by Draper and Brown (2004), is that it is not necessary for a student to emit an overt response during a passive lecture because so little mental processing takes place during the lecture. This view is contrasted by student response systems (SRS), which are technological devices used to promote active learning by increasing the opportunity for the student to respond during instruction. These technological devices are called a variety of names such as: student response systems (SRS), audience response systems (ARS), classroom response systems (CRS), interactive response systems (IRS), personal response systems (PRS), electronic voting systems (EVS) and clickers (Cain & Robinson, 2008). However, all of these systems are based on the three-term contingency also known as operant conditioning. The three term contingency for SRS is as follows. The antecedent is the instructor's verbal stimulus and/or the presentation of a visual stimulus. This stimulus is may be in the form of a question. The behavior portion of the contingency is the student's selection of an answer.

Finally, the consequence is any immediate feedback received by the student from the teacher and/or the computer system itself. This supports many years of research on best practice for learning techniques (Cooper, Heron, Heward 2007).

The idea of student response systems is not a new technology. Judson and Sawada (2002) stated that the technology on which SRS is based emerged from past technology such as the military's utilization of filmed instructional material. According to Abramsom (2006), mechanical response systems date back well over 40 years. Another example of early response systems is the Litton Student Response System. This system was comprised of a dial device that allowed the student to select five potential answers (A, B, C, D, E) by turning the dial to their choice and then selecting by pressing a button. The dial device immediately vibrated if a correct answer was selected. The teacher was able to discriminate between a correct and incorrect answer for each student by the illumination of a colored light. A green light signaled a correct response and a red light notified the teacher of an incorrect response (Boardman, 1968). Over time, active student response systems have evolved into more sophisticated devices due to advances in modern technology.

The current electronic student response systems allow students to actively take part in lectures by anonymously selecting and submitting responses to interactive questions such as multiple choice, true/false, or opinion questions previously selected by the instructor. The student's selections are made using a hand-held or computer device often called a clicker. Once the student has made a selection, a signal is sent to a sensor device that records the answer selections chosen by the students. According to Mula (2008) there are two major types of active student responding devices. One type of clicker uses radio frequency (RF). These clickers are the more expensive of the two but they are also more reliable for large lecture halls. The second type of clicker uses infrared (IF) technology. These clickers must have an unobstructed signal from the remote device to the receiver for a selection to be recorded. Finally, the answers selected by the students are uploaded into a computer program so the answers can be recorded and analyzed.

SRS computer programs often have numerous options for data display and student records. For example, the following are standard features included in most systems according to Caldwell (2007). First, it includes multiple-choice question formats with timers to establish classroom parameters for response time. The data may be identifiable or anonymously displayed as a group or individually. Most often it is displayed using a bar graph. An additional graphing feature is that the percentage of correct responses may be color-coded. The data are typically displayed immediately upon completion of each interactive question to serve as immediate feedback to the instructor and the student. The computer systems are able to track and store both individual or group data, and it may be displayed at selected intervals of time (e.g. daily, weekly, monthly, yearly).

Who uses electronic student response systems? There are numerous fields that have examined active student response systems as a means of instruction. The following is just a sampling of those fields: communications (Jackson & Trees, 2003), special education (Bicard et al, 2008), nursing (Halloran, 1995), psychology (Morgan, 2008), biology (Sokolove, Blunk, Flain, & Sinsha, 2011), engineering (van Dijk, van de Ber, & van Keulen, 2001) computer science (Draper & Brown, 2002), business (Walker, Cotner, Baepler, & Decker, 2008), and economics (Simpson & Oliver, 2005). The student response systems have been implemented in relatively small classrooms with as little as 15 students (Draper & Brown, 2002) and large lecture halls with well over 100 students (Stowell & Nelson, 2007). The electronic response system technology has been incorporated into classrooms of varying ages including K-12 (Roschelle, Penuel & Abrahamson, 2004; Johnson & McLeod, 2004), undergraduate classes (Walker et al., 2008), and finally graduate classes (Bicard et al., 2008).

How are electronic student response systems used? Most often the active student response questions are prepared before class and inserted into the lecture or discussion as needed (Caldwell, 2007). There are many forms of questions that can be developed by the instructor such as multiple choice, opinion, or true/false questions (Fies & Marshall, 2006). Caldwell listed many purposes for the student response systems questions. First, questions may be developed to evaluate students' preparedness for class. The questions incorporated by the teacher can be used to initiate or focus the discussion. Second, educators can use student response systems to conduct formative assessments. Third, tests and quizzes can also be completed using these systems. Fourth, these systems can track and record student responding (Caldwell, 2007).

Why are electronic student response systems used? There are many positive characteristics of SRS that may benefit students. First, these systems help to ensure preparedness by introducing accountability for all students (Knight & Wood, 2005). Second, clickers help teachers to actively engage students during the entire class period (Bachman & Bachman, 2011). Third by surveying or polling students, the instructors may be able to find more information out about each student's opinion (Fies & Marshall, 2006). Fourth, these systems provide students' with an increased opportunity since they are responding to all questions proposed by the instructor regardless of the class size (Poirier & Feldman, 2007). Fifth, anonymous responding is another benefit of this technology (Davis, 2003). Sixth by requiring the students to emit a response using a clicker following an antecedent, the students are allowed to “practice” and receive immediate feedback on their performance (Draper, Cargill & Cutts, 2002). The principles of applied behavior analysis support the notion that the more times a contingency is replicated or practiced the more likely learning will occur. According to the literature base, replication, immediacy and specificity of feedback are all characteristics identified to improve performance (Cooper et al., 2007). Seventh, these systems allow students to complete practice problems quickly and clarify any misunderstandings (Hake, 1998). Finally, according to many research studies, students report that student response systems make learning more fun (Boyle & Nicol, 2003; Caldwell, 2007).

There are also benefits of this technology for educators. First if the student is overtly emitting an electronic response to the instructional antecedent provided by the teacher, the teacher is provided feedback pertaining to student understanding in real time, which enables formative assessments to be completed (Hall et al., 2002; Wood, 2004). Second, since these assessments are being conducted during learning, they allow the teachers to adjust their lessons according to the needs of the students (Boyle & Nocol, 2003; Duncan, 2005). For example, if the entire class answers two questions correctly in a row on a particular topic, the teacher may decide to continue on to another topic. On the other hand, if a large number of students emit an incorrect response to the question presented, the teacher may potentially adjust his or her lecture to spend additional time focused on that particular topic. Third, these electronic response systems offer a simple means of data collection and record keeping especially for large classrooms, and the results are posted in a timely manner (Caldwell, 2007). Tests and quizzes are easily administered and graded using this technology, and again immediate feedback is available (Draper, 2002).

Detailed literature on student response systems. An empirical research base has begun to form investigating student response systems, but the data are spread throughout many disciplines, and there are still numerous gaps to be explored (Banks, 2006). Research does not always support the notion that students' academic achievement increases as a result of including electronic student response systems (Judson & Sawada, 2002). There are a small number of studies that do not report improvement in students' academic achievement when using student response systems. For instance, one study found no difference in grades when comparing clicker use with discussion to discussion with hand raising (Lasry & Findlay, 2007). Ewing (2006) found no effect on the implementation of clickers in relation to the final course grades. Martyn (2007) found that students who participated in the experimental condition with clickers preformed below their counterparts who participated in the traditional lecture with discussion condition. This supports the notion that this type of technology may not be effective or necessary in every circumstance or learning opportunity (Stowell & Nelson, 2007).

The unfavorable results reported may suggest it is not simply the integration of technology into the classroom that affects the student's academic achievement, but rather the underlying pedagogical practices of education with the new technology (Judson & Sawada, 2002). Morgan (2008) states, "the research to date seems to suggest it is how the instructor makes use of the clickers, rather than the simple adoption of clickers themselves, that determines their pedagogical effectiveness." According to Caldwell (2007), teachers should be cautious about the gimmicky use of technology because without purposefully linking the use of the devices to clear learning objectives the technology may not have the same effect on the learning. Even though slight variability exists in the literature concerning the effectiveness of using clickers in the classroom, active student responding via clicker use has become a relatively popular teaching technique (MacArthur & Jones, 2008). Thus, many would agree that student response systems when paired with the proper pedagogical methodologies improve student performance (Fies & Marshall, 2006).

Numerous research studies support the idea that electronic response systems increase student academic achievement (Bullock et al, 2002; Paschal, 2002; Poulis, Massen, Robens, & Gilbert, 1998; Reay, Bao, Pengfei, Warnakulasooriy, & Baugh, 2005; Kennedy, & Cutts, 2005). Several other studies revealed higher levels of student participation and engagement when utilizing student response systems by requiring sporadic engagement with the material throughout the lecture (Bullock et al, 2002: Paschal, 2002; Judson & Sawada, 2002; Walker, 2008; Barbetta et al. 1993; Boyle & Nicol, 2003). Also, there is evidence to support the notion that retention in students is better when information is presented in an active learning environment using electronic response systems rather than the traditional learning environment (Bicard et al., 2008). Other benefits of clickers that have been reported are that they not only improve academic achievement, but they can also increase motivation for students and facilitate an interactive relationship between a student and his or her teacher (Simpson & Oliver, 2005; Draper & Brown, 2002; Boyle, 1999; Bullock et al., 2002; Fies, 2005; Reay et al., 2005). Electronic response systems, when compared to other methods of active student responding, have shown an increase in response rates or opportunities to actively participate (Stowell & Nelson, 2007).

Studies comparing lecture to student response systems. First, a study conducted by Slain, Abate, Hodges, Strimatkis and Wolak (2004) compared pharmacy students' test scores at the university level over two academic years. The traditional lecture format was used during the first year and the lecture plus student response system format was implemented in the second year. The results revealed that the students' test scores were significantly greater in the lecture plus student response system condition, specifically on questions that required analytical thinking. Second, Poirier and Feldman compared two introductory to psychology classes for college students in which one class used an electronic student response system while the other class did not. They found final exam scores were significantly higher in the classroom that incorporated the use of clickers (Poirier & Feldman, 2007).

Third, Morling, McAuliffe, Cohen, and DiLorenzo (2008) conducted a study with introductory to psychology students at the university level. The students were divided into four classes. Two classes used clickers to answer multiple-choice questions for extra credit at the beginning of class. The remaining two classes did not use clickers, however the students were able to earn the same number of extra credit points by participating in another research study or completing additional reading. The results for this study showed a minimal increase in exam scores for the students who participated in the clicker condition.

Sokolove, Blunk, Flain, and Sinha (2011) conducted the final study examined by the researcher for this review. They compared the traditional lecture method to an active learning approach using clickers in an introductory biology class for college students. Final exams scores were compared at the conclusion of the semester to determine if any significant differences could be identified. The students that participated in the active learning sections scored higher on common multiple choice questions presented on the final examination. Also, the clicker group showed significant improvement when long-term learning was tested by comparing questions that were also asked on the midterm.

Social validity results for student response systems. "Clickers for the Classroom" was a campaign started by groups of parents and educators to support this technology. The campaign was launched to bring awareness to electronic response system interventions as a way to facilitate learning through active teaching methods. Many research studies have shown that it is not just parents and educators in favor of this technology, but students themselves support and prefer the use of this active learning approach as well.

Student opinions of electronic response systems are usually positive. In a study conducted by Bicard et al. (2008), 91% of the participants who completed a class using SRS technology stated that they had a positive experience, and 86% would endorse SRS for future curriculum. Patry (2009) used a seven-point scale to evaluate student's perceptions of clickers in the classroom with 1 representing "strongly disagree" and 7 representing "strongly agree". Based on the results, it was apparent that the students enjoyed the clickers ($M = 5.3$). The participants also felt that they were more engaged during class due to the presence of the clicker ($M = 5.1$), and their perception of the immediate feedback provided by the clicker was beneficial in understanding the course content (*M* = 5.2). Many other studies have found similar results (Keller et al., 2007; Kennedy & Cutts 2005; Poirier & Feldman, 2007).

Statement of the Problem

Many fads come into the field of education. Thus, empirical research studies must continue to help determine the future path of the educational system by ensuring that the allocation of federal and state funds are used to support the most effective methods of teaching. For example, it is generally accepted that classrooms which incorporate an active approach to learning such a student response system as an instructional method lead to greater improvement in student achievement when compared to "traditional" passive academic environments (Fies & Marshall, 2006). However, even though the student response system technology is generally accepted as effective, it is still necessary to obtain a better understanding of this technology's applications and limitations (Penuel et al., 2004).

Fies and Marshall (2006) conducted an extensive literature review on classroom response systems (CRS) also know as student response systems (SRS). Based on the vast amount of literature reviewed, it was concluded that student response systems were well known in school settings, and their utilization will likely continue to grow. However, there were several gaps identified in the literature that were suggested as future areas of research. The first area mentioned as needing additional examination was "Tightly controlled comparison studies in which the only difference is the use, or lack of use, of a CRS" (Fies & Marshall, 2006, p. 106). This type of research would directly compare passive learning environments pedagogies to active learning environments pedagogies.

Another area that was discussed as an implication for further research was "CRS use in connection with diverse populations and content areas" (Fies & Marshall, 2006, p. 106). In other words, inclusive classrooms that incorporate students without disabilities as well as students with disabilities is an area in which further research is needed to examine the effectiveness of this technology. Another area lacking in the literature that was identified to be in need of more supporting research was the expansion of participants from differing levels of education. There are numerous studies at the college level that have revealed positive findings for electronic student response systems (Draper & Brown, 2004; Judson & Sawada, 2002; Kennedy & Cutts, 2005), but fewer are examined at the high school level (Conoley, 2005). The lack of empirical research addressing student response systems compared to lecture and student response systems utilized in different setting with varied populations is a significant problem that yields the need for additional research.

Purpose of Study

In an attempt to address the aforementioned shortcomings, this study was designed to expand the literature by comparing the effects of passive learning (lecture method) versus active learning (lectures plus student response systems) on students' academic achievement by merely manipulating the presence or absence of the student response system or clicker. The second aim of this study was to begin collecting data pertaining to the implementation of student response systems or clickers as an instructional method with high school students in both a non-inclusive and an inclusive classroom. As previously mentioned, the majority of previous studies were conducted with students in university settings. The final shortcoming addressed by this study was the need for additional research with differing populations of students. The students in this study were not only students without disabilities but students with disabilities as well.

Research Questions

The present study examined the following research questions:

1. Which instructional method, lecture or lecture plus student response system, is the most effective in increasing students' academic performance in a non-inclusive class?
2. Which instructional method, lecture or lecture plus student response system, is the most effective in increasing students' academic performance in an inclusive class?
3. What are the differences between two instructional methods, lecture and lecture plus student response system, when comparing students' academic achievement between a non-inclusive class and an inclusive class?
4. Which instructional method, lecture or lecture plus student response system, is the most effective in increasing students with disabilities' academic performance?

Hypotheses

1. The lecture plus student response system instructional method will be the most effective in increasing students' academic performance in the non-inclusive class.
2. The lecture plus student response system instructional method will be the most effective in increasing students' academic performance in the inclusive class.

3. The lecture plus student response system instructional method will be equally effective on increasing students' academic performance in both the non-inclusive and the inclusive class.
4. The lecture plus student response system instructional method will be the most effective in increasing students with disabilities' academic performance.

CHAPTER 3: Method

The purpose of this chapter is to provide a description of the methods followed to conduct the current study in order to answer the previously presented research questions. This chapter describes in detail the following: (a) setting, (b) participants, (c) materials, (d) equipment, (e) measures, (f) independent variables, (g) dependent variable, (h) experimental design (i) procedures and (j) reliability. The intent of this study was to compare the effects of two instructional methods lecture and lecture plus student response systems delivered during both a non-inclusive and an inclusive class on students' academic achievement.

Setting

This research study was conducted in a biology classroom at a public high school located in a small rural school district in northwest Tennessee. This study was conducted during two sections of a physical science class. One of the class sections was a non-inclusive class. The other section was characterized as an inclusive class due to the integration of students with disabilities. The classroom layout consisted of student desks aligned in rows facing a large projection screen at the front of the classroom, and a dry erase board located to the right of the students' desks. The teacher's desk was located next to the projection screen at the front of the classroom.

Participants

The participants for this study included a volunteer physical science teacher and physical science students whom are described in more detail below.

Teacher. The volunteer classroom teacher was a 28 year old female with six years of classroom teaching experience. She was a secondary education teacher who held an educational specialist degree (Ed.S). The volunteer teacher was certified in biology and administration. This teacher was the instructor for both sections of the participating physical science classes.

Students. The number of participants was 58. The participants were naturally divided into groups: one inclusive class and one non-inclusive class. Table 1 below illustrates a breakdown of the demographic variables for the participants divided into class (inclusive vs. non-inclusive).

Table 1

Frequencies and Percentages for Demographic Variables (Non-inclusive vs. Inclusive)

	Non-inclusive		*Inclusive*	
Research variable	*N*	*%*	*N*	*%*
Gender				
Male	*19*	*65.5*	*10*	*34.5*
Female	*10*	*34.5*	*19*	*65.5*
Ethnicity				
African American	*4*	*13.8*	*2*	*6.9*
Asian American	*2*	*6.9*	*1*	*3.4*
Caucasian	*23*	*79.3*	*26*	*89.7*
Grade				
Ninth	*29*	*100.0*	*26*	*89.7*
Tenth	*0*	*0.0*	*3*	*10.3*
Age				
14	*18*	*62.1*	*11*	*37.9*
15	*11*	*37.9*	*14*	*48.3*
16	*0*	*0.0*	*4*	*13.8*

Students without disabilities. To determine if the students were academically similar across the two classrooms (non-inclusive and inclusive), the students' letter grades were compared for the nine-week grading period prior to the start of the study. The scale used was as follows: A = 93-100, B = 85-92, C = 75-84, D = 70-74, and F = 0-69. First, the total number of students for each category in the non-inclusive was calculated. The data revealed that four students earned an A during the previous nine weeks. There were also 10 B's, 11 C's, 2 D's and 2 F's earned during that same grading period. Next, the total number of students without disabilities for each category in the inclusive class was calculated. The letter grades for the students with disabilities are reported in the following section. The data showed that four students earned an A and eight students earned a B. The remainder of the letter grades were as follows: 9 C's, 4 D's, and 3F's.

Students with disabilities. There were two students with disabilities that participated in this study. Both of the students diagnosed with intellectual disabilities that participated in this research project were male and freshman in high school. Also, both students earned a D during the previous nine-week grading period. Student A was African American and had been in the special education system for 10 years. This student had an IQ of 88, and he was diagnosed as learning disabled. His test scores showed major discrepancies in all areas of reading and math.

Student B was Caucasian and had been in the special education system for 8 years. He also had a diagnosis of learning disabled. His IQ score was documented at 86. His test scores showed that his area of concern was reading comprehension only. Both students were eligible for accommodations in their physical science classroom.

The available accommodations were additional cues and prompts provided by the teacher, preferential seating, oral testing, and the availability of extra assignments. Table 2 shows a breakdown of the demographic variables for the total number of participants divided into categories (students with disabilities vs. students without disabilities).

Table 2

Frequencies and Percentages for Demographic Variables (Students without Disabilities vs. Students with Disabilities)

	Students Without Disabilities		Students With Disabilities	
Research variable	*N*	%	*N*	%
Gender				
Male	27	93.1	2	6.9
Female	29	100.0	0	0.0
Ethnicity				
African American	5	8.6	1	1.7
Asian American	3	5.2	0	0.0
Caucasian	48	82.8	1	1.7
Grade				
Ninth	53	91.4	2	3.4
Tenth	3	5.2	0	0.0
Age				
14	29	50.0	0	0.0
15	24	41.4	1	1.7
16	3	5.2	1	1.7

Materials

Consent forms. Prior to the beginning of the study, the teacher's consent (see Appendix A) was obtained along with guardian consent via a guardian consent form (see Appendix B). Both of these consent forms included the purpose of the study, a description of the procedures, the approximate duration, the potential risks and benefits, the protocol for confidentially and other specific information required by the university Institutional Review Board (IRB). The guardian consent form clearly stated that consent was voluntary and no negative consequences would be applied if consent were declined. This form also emphasized that neither the student's scores on the pretests nor posttests would affect the student's class grade in any way. This form was sent home with each individual student. If deemed appropriate by the guardian, the forms were returned and presented to the teacher before participation was allowed. 100% of the forms were signed and returned. An assent consent form developed in age appropriate vernacular was then presented to the students and signed by students who chose to participate (see Appendix C). Permission was also obtained from the participating school's principal (see Appendix D). IRB approval was requested and obtained.

PowerPoint® lectures. There were a total of 12 lectures based on the learning objectives set by the classroom teacher for each session (see Appendix E). Twelve randomly dispersed interactive multiple-choice questions were included in six of those lectures. The remaining six lectures were merely composed of lecture slides without interactive questions. The topics taught during this project included: classification of matter, properties of atoms, and the periodic table. The lectures were mandatory as a class requirement, but participation in the study was completely voluntary. The study did not interfere with the normal classroom curriculum.

Equipment

Technological devices. A pc laptop equipped with the TurningPoint Technologies computer software was used. The PowerPoint® slides originated on the laptop and were projected onto a projection screen mounted to the ceiling near a main wall at the front of the classroom.

Student response system. The TurningPoint Technologies student response system used included a classroom set of clickers, a receiver, and access to the computer program that interfaces with the computer and the receiver to record all student responses in a database (see Appendix F).

Measures

Pretest and posttest. These identical tests were comprised of 10 multiple-choice questions covering the material presented during each class period (see Appendix G). Each question consisted of four answer options with one correct answer. The pretest was administered prior to the lecture to measure pre-existing knowledge and a posttest was administered after the lecture to measure academic achievement. These measures are described in great detail in the procedures section.

Demographic questionnaire. This questionnaire examined gender, ethnicity, grade, and age. Each category was polled in a multiple-choice fashion. (see Appendix H)

Social validity questionnaire. This survey consisted of four questions that investigated the participating students' opinions and perceptions concerning the student response systems (see Appendix I). The possible answers to each question ranged from strongly disagree to strongly agree.

Teacher's treatment integrity checklist. The purpose of this checklist was to ensure accurate implementation of the research protocol by the teacher. The teacher and the researcher used identical checklists during the study (see Appendix J). This checklist was divided into lecture and lecture plus the use of the student response system. There were 10 criterion the teacher was expected to master during each session.

Independent Variables

Lecture and lecture plus student response systems were the two independent variables (IV) manipulated in this study. The independent variables were presented in both a non-inclusive class and an inclusive class setting. The independent variables were also applied to students with disabilities and students without disabilities.

Dependent Variable

The dependent variable (DV) measured during this study was students' academic achievement. Students' academic performance was measured by administering a 10 item multiple-choice test before each intervention condition and the same 10 item multiple-choice test after each intervention condition.

Experimental Design

The experimental design used in this study was a counter balanced alternating treatment design (ATD). A counter balanced ATD was chosen by the researcher so that each condition could be rapidly alternated between sessions independent of the level of responding. This design allowed the researcher to examine the effects of differing teaching pedagogies on the participating students' academic performance in a timely manner.

The present study included a total of six class periods for both the non-inclusive class and the inclusive class. Each class experienced the lecture condition for three sessions and the lecture plus student response system condition for three sessions. The initial condition for the non-inclusive class was randomly established by flipping a coin prior to the study. It was determined that this class would start in the lecture condition (L). Thus, the lecture plus student response system condition (SRS) was determined to be the second condition introduced. The alternating sequence for the non-inclusive class was as follows (L), (SRS), (L), (SRS), (L), and (SRS). In order to counter balance the design, the inclusive class began the study in the lecture plus student response system condition. Then, the lecture condition was implemented. The sequence for the inclusive class was as follows (SRS), (L), (SRS), (L), (SRS), and (L).

Procedures

Lecture development. Prior to the present study, the teacher was not incorporating PowerPoint® slides into her presentations as a teaching strategy. Lectures were developed for the purpose of this study. The teacher and the researcher incorporated both standard slides that were provided with the teacher's manual as well as taken new slides into the PowerPoint® presentation (McLaughlin, Thompson, & Zike, 2010). In an attempt to avoid potential bias, the lecture content and learning objectives were not selected by the researcher. They were merely the next scheduled subject area to be covered in the participating physical science classrooms. However, the participating teacher and the researcher worked collaboratively to develop the pretests, posttests, lecture slides, and interactive questions covering the subject matter at hand.

Teacher Training. Prior to the start of the study, the teacher was instructed by the researcher to avoid asking any questions during the PowerPoint® presentations in either treatment condition for the duration of the study. The teacher was also instructed to avoid answering any questions asked during the Power Point® presentations. If a student proposed a question during either treatment condition, the teacher merely stated all questions would be answered following the posttest. These instructions were given to ensure each class received the same instruction during each session in an attempt to avoid confounding variables.

Student training. The volunteer teacher was already using clickers in her classroom prior to this study. Thus, all of the students had already been assigned a student response system clicker at the beginning of the year. However, it is important to note that the teacher was not using clickers within her lecture presentations. A brief training was conducted on the first day of the study for both classrooms to ensure that each student had mastered the use of his or her individual clicker. Accuracy was ensured during the demographics questionnaire that was administered via the clickers. For example, the teacher and the researcher counted the number of females and males in each class, and then compared the frequencies to the responses provided by the participants. 100% accuracy was documented for both classrooms during the demographic questionnaire. This reliability check was only conducted on the first session for each of the classrooms.

Pretest. At the beginning of each lecture condition and each lecture plus student response system condition, all students were asked to complete a 10 item multiple-choice pretest using their student response system or clicker. The pretest questions were based on the learning objectives for the material that would be covered during that session. The computerized pretest displayed one multiple-choice question per slide for 30 seconds starting with question one. Each question was displayed onto a large projection screen located at the front of the classroom. A visual prompt or timer was included on each slide to indicate the remaining available time for the students to respond to the proposed question. Each slide also included an interactive response table. This interactive table was presented to ensure that each student's answer was entered and recorded by the system. Thus, once an answer was entered and recorded into the student response system, the student's clicker number was highlighted on the table. A highlighted clicker number indicated a successful submission of that particular students answer to both the individual student and the teacher. Once the 30-second response time interval ended, the next question was displayed onto the projection screen. The duration for each of the pretests was 5 minutes. The pretest served as a baseline to determine which intervention was more effective for the student's academic achievement immediately following each condition. Next, the teacher would begin either the lecture condition or the lecture plus student response system condition.

Lecture condition. During the sessions designated to the lecture condition, the teacher delivered a lecture with accompanying Power Point® slides. The teacher presented the lecture in a predetermined order that was established based upon the sequence of the questions in the pretest and posttest. The duration of the lecture condition varied depending on the learning objectives identified for that class session. Upon the conclusion of the lecture presentation, a posttest was administered.

Lecture plus student response system condition. During each session designated lecture plus student response system, the teacher delivered a lecture with accompanying PowerPoint® slides that incorporated active student responding via the student response system throughout the lecture. The PowerPoint® presentation in this condition was identical to the PowerPoint® presentation in the lecture condition with the exception of opportunities for each student to respond throughout the presentation. Twelve interactive multiple-choice questions were presented during the PowerPoint® lecture, and the students were prompted to select and enter their answer by using the student response system or clicker. The system was set up to allow 30 seconds per question for each student to contemplate his or her answer. At the end of the response interval, the frequencies of student responses were displayed in a bar graph on the projection screen. This visual display highlighted the correct response. Then, the teacher provided feedback based on the students' responses. For example, "Good work, you all selected the correct answer." However, the teacher neither gave corrective feedback nor did she re-teach any material below mastery. The researcher determined, in order to measure the effectiveness of the student response system as a technology, the teaching strategies across conditions had to be identical. The duration of the lecture plus student response system condition varied depending on the learning objectives identified for that class session. Once the lecture plus student response system presentation was finished, a posttest was immediately given.

Posttest. A posttest was administered immediately following the lecture condition as well as the lecture plus student response system condition using the active student response system or clicker. The same process for presenting and responding via the student response system used during the pretest was utilized during the administration of the posttest. The posttest questions were identical to the pretest questions. Thus, the duration of the posttest was also 5 minutes.

Social validity questionnaire. Upon the conclusion of the study, the students from each class (non-inclusive and inclusive) were asked to complete a social validity questionnaire to measure their perception of the student response system. The questionnaire included questions to indicate the extent to which the clickers helped the participants, as well as, questions regarding the participants' general attitude toward the student response system. All questions were presented using a five-point Likert Scale. The scale was as follows 1) "strongly disagree", 2) "disagree", 3) "neither agree nor disagree", 4) "agree" and 5) "strongly agree".

Reliability

Interrater agreement. Interrater agreement (IRA) was conducted to help ensure reliability in the data. The teacher for 30% of the pretests and 30% of the posttests hand calculated the total number correct for each pretest and posttest reviewed. Then, those calculations were compared to the computer-generated scores to ensure reliability. The formula used to calculate interrater agreement was trial-by-trial and the equation used was: divide the number of items in which the graders agreed by the number of agreements plus disagreements and then, multiply that number by 100 (Cooper et al., 2007). The IRA results revealed that the teacher and the computer were in 100% agreement.

For the remainder of the IRA results, the procedures used were the researcher and a secondary observer independently scored 100% of the dependent variable measures collected during this study. Once both observers completed scoring the dependent measures, IRA was calculated using the same formula previously described. IRA was calculated for 100% of the pretests and posttests for each group during each session. These results are displayed in Table 3. IRA was also computed for 100% of the mean change scores reported in both the non-inclusive and inclusive class. These results are displayed in Table 4. Table 5 shows IRA for the overall change scores reported for each intervention (lecture and SRS). Finally, Table 6 shows IRA results for both students with disabilities change scores for each session. IRA was conducted for 100% of the change scores shown for students with disabilities.

Table 3

Interrater Agreement as a Percentage by Class (Non-inclusive vs. Inclusive) for Pretest and Posttest Scores

	Non-inclusive		Inclusive	
Sessions by Day	*Pretest*	*Posttest*	*Pretest*	*Posttest*
1	100*	97*	100	100
2	100	100	97*	97*
3	100*	100*	100	100
4	100	100	100*	100*
5	100*	93*	100	93
6	97	100	100*	100*
Overall IRA Score	99		99	

Note. * = SRS

Table 4

Interrater Agreement as a Percentage by Class (Non-inclusive vs. Inclusive) for Mean Change Score per Session

Sessions by Day	Non-inclusive *Change Score*	Inclusive *Change Score*
1	100*	100
2	97	100*
3	100*	96
4	100	96*
5	97*	96
6	100	100*
Overall IRA Score	99	98

Note. * = SRS

Table 5

Interrater Agreement as a Percentage by Class (Non-inclusive vs. Inclusive) for Overall Mean Change Score per Invention (Lecture vs. SRS)

Intervention	Non-inclusive *Overall Mean Change Score*	Inclusive *Overall Mean Change Score*
Lecture	100*	100
SRS	100	100*

Note. * = SRS

Table 6

Interrater Agreement as a Percentage for Change Scores per Session for Students with Disabilities

	Student A	Student B
Sessions by Day	*Change Score*	*Change Score*
1	100	100
2	100*	100*
3	100	100
4	100*	100*
5	100	100
6	100*	100*
Overall IRA Score	100	100

Note. * = SRS

Treatment Integrity. Treatment integrity or procedural fidelity was used to ensure accurate and consistent execution of the research procedures throughout the study. Prior to the start of the study, the researcher observed each class for one class period in an attempt to decrease reactivity from the students. Both the researcher and the teacher used a treatment integrity checklist during each session throughout the study to collect the treatment integrity data. The teacher scored 100% throughout the study.

CHAPTER 4: Results

The purpose of this chapter was to examine the effects of two instructional interventions (lecture and lecture plus student response system) on students' academic achievement in a non-inclusive and an inclusive class. The effects of lecture and lecture plus student response systems were also examined for two students identified with learning disabilities. The effects were determined by collecting data on students' academic achievement by administering a pretest and a posttest for each treatment condition. The results were analyzed by visually displaying the data on graphs. Social validity data were collected to measure the students' subjective perceptions of social acceptability, social significance and social importance of student response systems. The results of this study are presented based on the order of the aforementioned research questions followed by the social validity findings.

Research Question 1

> RQ1: Which instructional method, lecture or lecture plus student response system, is the most effective in increasing students' academic performance in a non-inclusive class?

The line graph below (Figure 1) compares the effects of two interventions (lecture and SRS) on students' academic achievement in a non-inclusive class using an alternating treatment design. During each intervention condition (lecture and SRS), both a pretest and a posttest was administered to capture the academic achievement of each participating student. Academic achievement for the purpose of this study was measured using change scores. Change scores are a common way used to compare pretest scores before and posttest scores after an intervention implementation. The formula used to calculate change scores was: posttest score minus pretest score.

In figure 1 below, the x-axis labeled sessions represents sessions across time. For this study, a session was defined as one physical science class period. The interventions (lecture and SRS) alternated across daily sessions. The dotted black data path represents the lecture condition, and the solid black data path represents the SRS condition. The first intervention implemented in this class was the SRS condtion. Then, the lecture intervention condition was introduced. The intervention conditions continued this alternating pattern across time for the duration of the study. The y-axis labeled average change score represents the mean change score for the class during each intervention session. The mean change score for each session was calculated by adding each individual student's change score and then dividing that score by the total number of students.

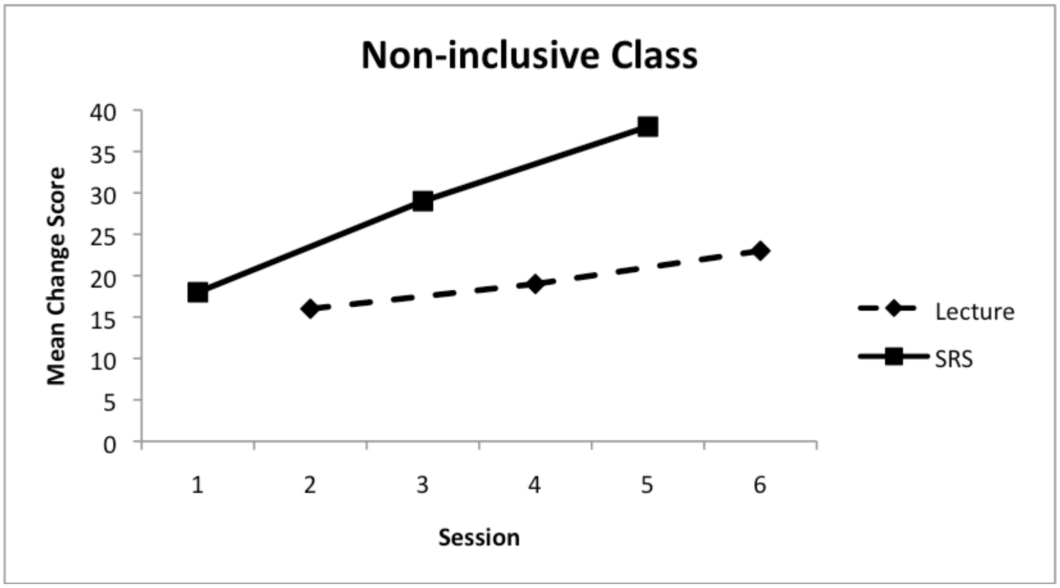

Figure 1. Mean change scores by intervention. This figure illustrates lecture versus SRS for the non-inclusive class.

The results from the non-inclusive classroom for both lecture and SRS interventions are displayed in Figure 1. A visual analysis was perfomed which focused on the separation of the data paths for the treatment conditions (lecture and SRS) to determine experimental control. The intervention data paths did not overlap with one another. This indicates differential effects were present between the interventions (lecture and SRS). The lack of overlap helps support a case of clear experimental control. The degree of differential effects produced by the two treatment conditions were measured by the vertical distance between each data path. The lowest average change score from prestest to posttest reported in the lecture condition was 16. The lowest SRS average change score from pretest to posttest was 18. This is a 2 point difference in the favor of the SRS condition. The highest mean change score during the lecture condition was 23. The highest mean change score during the SRS condition was 38. This is a 15 point difference in support of the SRS condition. The highest overall mean change score was reported in the SRS condition. The lowest overall mean change score occurred during the lecture condition

The results in Table 7 show that the implementation of either intervention (lecture or SRS) was successful in increasing the overall mean change score of the students' academic achievement in the non-inclusive class. The overall mean change score for both lecture and SRS was determined by adding each intervention session's mean change score and then dividing that score by the total number of sessions. The results revealed the SRS intervention was more effective than the lecture intervention when examining the overall mean change scores of academic performance.

Table 7

Overall Means and Standard Deviations on Change Scores by Intervention (SRS vs. Lecture) in the Non-inclusive Class

Intervention	Class	*M*	*SD*
SRS	Non-inclusive	28.07	21.58
Lecture	Non-inclusive	19.17	17.30

In conclusion, the data presented in Figure 1 and Table 7 support the notion that both lecture and student response systems are effective in increasing student performance. However, the student response system intervention was more effective than the lecture intervention in increasing students academic achievement in a non-inclusive classroom.

Research Question 2

RQ2: Which instructional method, lecture or lecture plus student response system, is the most effective in increasing students' academic performance in an inclusive class?

The second research question (RQ2) compared the effects of two interventions (lecture and SRS) on students' academic acheivement in an inclusive classroom. A pretest and a posttest was administered to measure the academic acheivement of each participating student during each intervention condition (lecture and SRS). Again, academic achievement was measured using change scores. The same formula used to calculate change scores for the non-inclusive class was also used to compute the change scores for the students in the inclusive class. The formula utilized was: posttest score minus pretest score.

Sessions across time are displayed on the horizontal axis of Figure 2. Again, a session represents a single physical science class period. A single intervention was utilized during each session, and a session occurred only once per day. The inclusive classroom followed the same alternating treatment design as the non-inclusive classroom. However, the sequence of the intervention conditions was reversed. This class began with the lecture intervention followed by the SRS intervention. This pre-established order was applied across time for the duration of the study. The sessions were counterbalanced across classrooms in an attempt to increase the probability that any observed difference in the students' academic achievement was the result of the intervention variables. In Figure 2, the lecture condition is represented by a dashed black data path. The SRS condition is represented by a continuous black data path. The vertical axis labeled average change scores represents the mean change score for the inclusive class during each intervention session. This score was determined by adding each individual student's change score and then dividing that score by the total number of students.

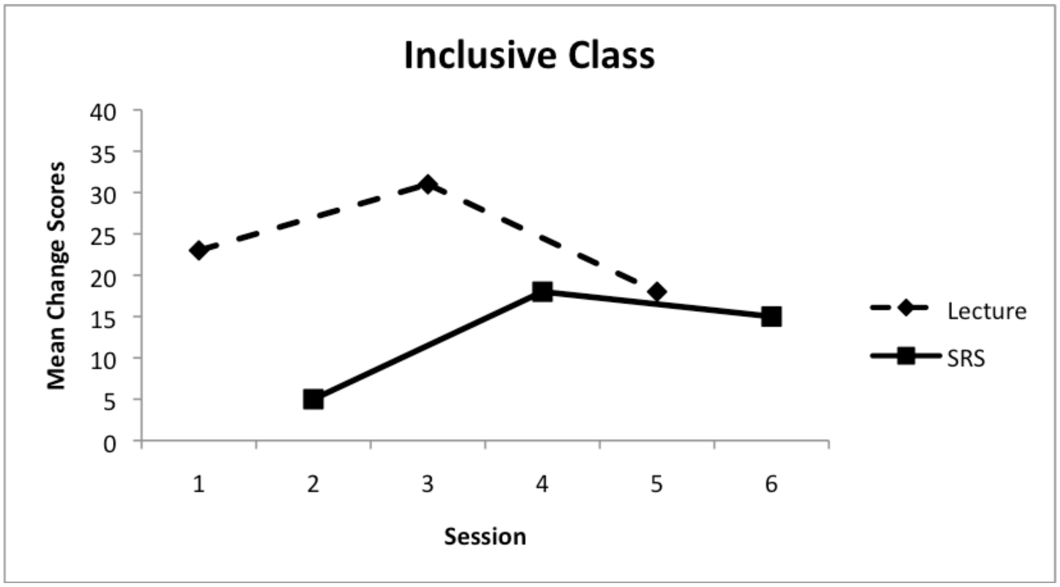

Figure 2. Mean change scores by intervention. This figure illustrates lecture versus SRS for the inclusive class.

A visual analysis was conducted on Figure 2 to help determine the most effective intervention method (lecture or SRS) in an inclusive classroom. The degree of differential effects produced by the two treatment conditions were measured by the vertical distance between each data path. The result of this analysis indicated minimal differential effects or experimental control were present between the interventions (lecture and SRS). The lowest mean change score from pretest to posttest reported in the lecture condition was 18. The lowest SRS mean change score from presttest to posttest was 5. This is a 13 point difference in the favor of the lecture condition. The highest mean change score during the lecture condition was 31. The highest mean change score during the SRS condition was 18. This is a 13 point difference in support of the lecture condition. The highest overall mean change score was reported in the lecture condition although the lowest overall mean change score occurred during the SRS condition.

Table 8 shows the results from the inclusive classroom for both the lecture and SRS interventions. The results revealed that the implementation of both interventions (lecture and SRS) improved the mean change score of the students in the inclusive class. The overall mean change scores representing academic achievement reported in Table 8 were calculated by adding each intervention sessions mean change score and then dividing that score by the total number of sessions. The lecture intervention was more effective than the SRS intervention in increasing the students' overall academic achievement.

Table 8

Overall Means and Standard Deviations on Change Scores by Intervention (SRS vs. Lecture) in the Inclusive Class

Intervention	Class	*M*	*SD*
SRS	Inclusive	12.35	20.33
Lecture	Inclusive	24.19	21.61

The data in Figure 2 and Table 8 provide evidence to support both lecture and student response systems as valuable instructional methods to increase students' academic performance in an inclusive classroom. However, the lecture intervention was more effective than the student response intervention in increasing students' academic achievement in the inclusive class setting.

Research Question 3

RQ3: What are the differences between two instructional methods, lecture and lecture plus student response system, when comparing students' academic achievement between a non-inclusive class and an inclusive class?

The purpose of the third research question (RQ3) was to examine the effects of two interventions (lecture and SRS) between a non-inclusive class and inclusive class. In Figure 3, the change scores reported are the same change scores that were reported for RQ1 and RQ2. However, Figure 3 was included as an additional analysis to aid in making comparisons for the two inventions (lecture and SRS) between the non-inclusive and the inclusive class.

The bar graph below is divided by classroom (non-inclusive and inclusive) and by instructional method (lecture and SRS). First, the non-inclusive class data are displayed. Then, the inclusive class data are presented. Both class data sets are presented with sessions on the x-axis and mean change scores along the y-axis. For each class, the black bar represents the lecture condition. The gray bar denotes the lecture plus student response system condition.

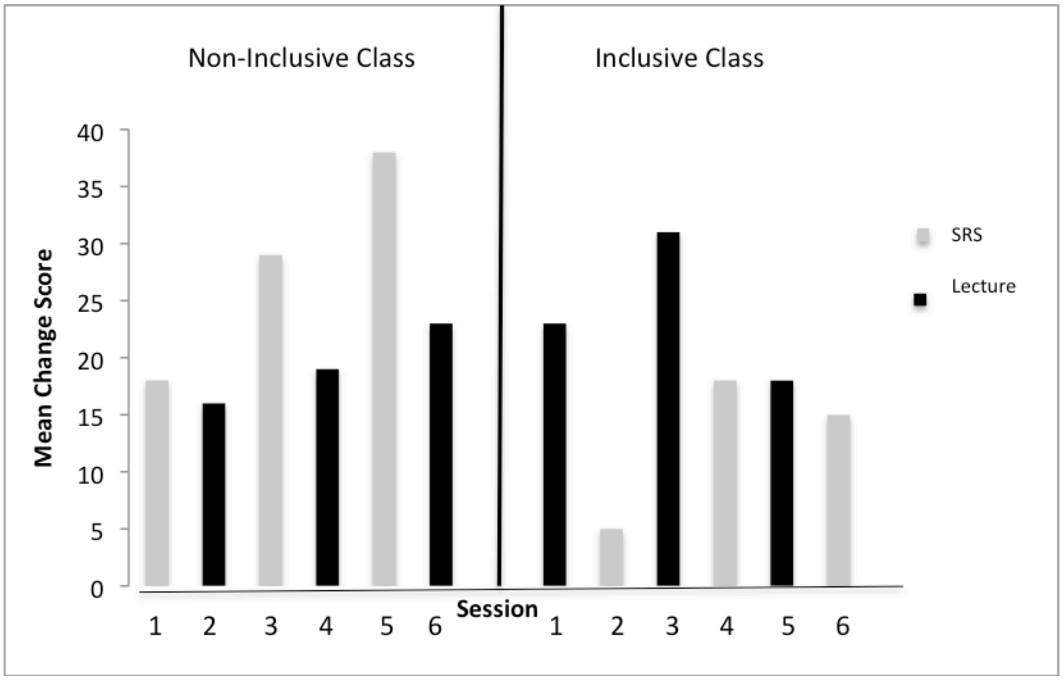

Figure 3. Mean change score by intervention. This figure illustrates lecture versus SRS by class (non-inclusive vs. inclusive).

A visual analysis of Figure 3 was conducted to determine the most effective method (lecture vs. SRS) for each class (non-inclusive and inclusive) as well as across classrooms. In the non-inclusive class the SRS condition sessions (gray bars) were consistently higher than the lecture condition sessions (black bars). The lecture only condition sessions (black bars) were consistently higher than the SRS sessions (gray bars) for the inclusive class.

When comparing the SRS condition sessions across classrooms, it is evident that each SRS session in the non-inclusive class was consistently greater than or equal to the SRS sessions in the inclusive class. However when comparing the lecture condition sessions across classrooms, it is apparent that each lecture condition session in the non-inclusive class was less than or equal to each lecture condition session in the inclusive class.

Table 9 shows the results from the non-inclusive and inclusive classroom for both the lecture and SRS interventions. The findings revealed that the implementation of both interventions (lecture and SRS) improved the overall mean change score of the students in both the non-inclusive and the inclusive class. The overall mean change scores representing academic achievement reported in Table 9 were calculated by adding each intervention sessions mean change score and then dividing that score by the total number of sessions. The SRS intervention was more effective in increasing students' overall academic performance in the non-inclusive class, although the lecture intervention was more effective in increasing the students' overall academic achievement in the inclusive class.

Table 9

Overall Means on Change Scores by Intervention (SRS vs. Lecture) by Class (Non-Inclusive vs. Inclusive)

Intervention	Class	*M*
SRS	Non-inclusive	28.07
SRS	Inclusive	12.35
Lecture	Non-inclusive	19.17
Lecture	Inclusive	24.19

In conclusion, the data reported in both Figure 3 and Table 9 support the finding that both instruction methods (lecture and SRS) were effective in increasing students' academic performance in both classrooms (non-inclusive and inclusive). The students from the non-inclusive class performed best during the SRS intervention condition. However, the students from the inclusive class performed best during the lecture condition.

Individual Scores. The individual scores for each student were analyzed for trends by determining the overall change score for each condition (lecture and SRS). The individual change scores were calculated by subtracting the pretest score from the posttest score. Then, the overall mean change score for each condition was calculated by using the following formula: add the change scores for each intervention session and then divide by the total number of sessions. Then, the researcher grouped the overall mean change scores for each condition (lecture and SRS) into ranges by class (non-inclusive and inclusive). To review each student's individual change scores (see Appendix K).

Non-inclusive class. The total number of students included for this analysis was 24. Five students did not participate in all of the lecture sessions, thus those students' data were not included in analysis below. The results for the non-inclusive class during the lecture condition were (0) = 1, (1-4) = 8, (5-8) = 11, (9-12) = 4, and (13-16) = 0. In other words, one student had an overall change score of 0 during the lecture condition.

The total number of students included in the analysis of the SRS condition in the non-inclusive class was 26 due to missing sessions. The results for the non- inclusive class during the SRS condition were (0) = 0, (1-4) = 2 (5-8) = 12, (9-12) = 10, and (13-16) = 2. For example, two students had an overall gain score between 1 and 4.

The majority of students in the non-inclusive class had an overall gain between 5 and 8 points during the lecture condition. During the SRS condition, the majority of students also had an overall gain between 5 and 8 points.

Inclusive class. The total number of students included for this report was 23. Six students did not participate in all of the SRS sessions, and those students' data were not included in analysis below. The results for the non-inclusive class during the lecture condition were (-8 - (-5) = 0, (-4 - (-1) = 1, (0) = 0, (1 - 4) = 5, (5 - 8) = 9, (9 - 12) = 5, and (13 - 16) = 3. In other words, one student had an overall change score between -4 and -1. The two students with disabilities' data were included in the above reported ranges. Both Student A and Student B with disabilities' overall mean change score for the lecture condition fell into the 5-8 range.

The total number of students included for the analysis of the SRS condition was 24 due to five students not participating in all of the SRS sessions. The results for the inclusive class during the SRS condition were (-8 - (-5) = 1, (-4 - (-1) = 0, (0) = 3, (1 - 4) = 11, (5 - 8) = 6, (9 - 12) = 2, and (13 - 16) = 1. During the SRS condition, both Student A and Student B with disabilities' overall mean change score for the SRS condition fell into the range of a 1-4 point gain.

The majority of students in the inclusive class had an overall gain between 5 and 8 points during the lecture condition. Both students with disabilities scores fell within the most common range of 5-8. During the SRS condition, the majority of students had an overall gain of between 1 and 4 points. Again, both students with disabilities' scores fell within the most common range of 1-4.

Research Question 4

RQ4: Which instructional method, lecture or lecture plus student response system, is the most effective in increasing students with disabilities' academic performance?

The purpose of the fourth research question (RQ4) was to compare the effects of lecture and SRS on the academic achievment of two students with disabilities. An alternating treatment design was used to determine if any differential effects were present for either intervention. This single subject analysis enabled the researcher to evaluate the treatment effects of each intervention at the level of the individual student.

Each of the line graphs below (Figure 4 and Figure 5) compare the outcome of two interventions (lecture and SRS) on an indivdual student with disabilities academic acheivement. The x-axes indicate sessions which were characterized as one physical science class period. Both students participated in one intervention session per day during which a single intervention method was implemented. Both of the students with disabilities were first exposed to the lecture intervention. Then, the SRS intervention was presented to each of the particpants. The intervention conditions followed the same sequence for the remainder of the study. On both graphs, the dotted black data path denotes the lecture condition, and the solid black data path symbolizes the SRS condition. There are three data points in each condition for each student with the exception of Student B. There are only two data points reported in the SRS condition for that student. This is discussed in more detail later in the limitations section. The y-axes are labeled change score. Change scores were chosen to represent the academic achievement for each student. Change scores were computed by subtracting the number of questions answered correctly on the pretest from the number of questions answered correctly on the posttest for each session.

Student A. Figure 4 shows the results for Student A with disabilities. The data paths for both the lecture and SRS conditions were variable and clear experimental control was not demonstrated. This was evident by the overlapping data. Neither the lecture condition nor the SRS condition indicated a clear trend. During the lecture condition, the change scores ranged from -2 to 4. Although the change scores ranged from -1 to 3 in the SRS condition. The highest change score of 4 correct answers gained from pretest to posttest occurred in the lecture condition. The lowest change score also occurred in the lecture condition with 2 correct answers lost from pretest to posttest.

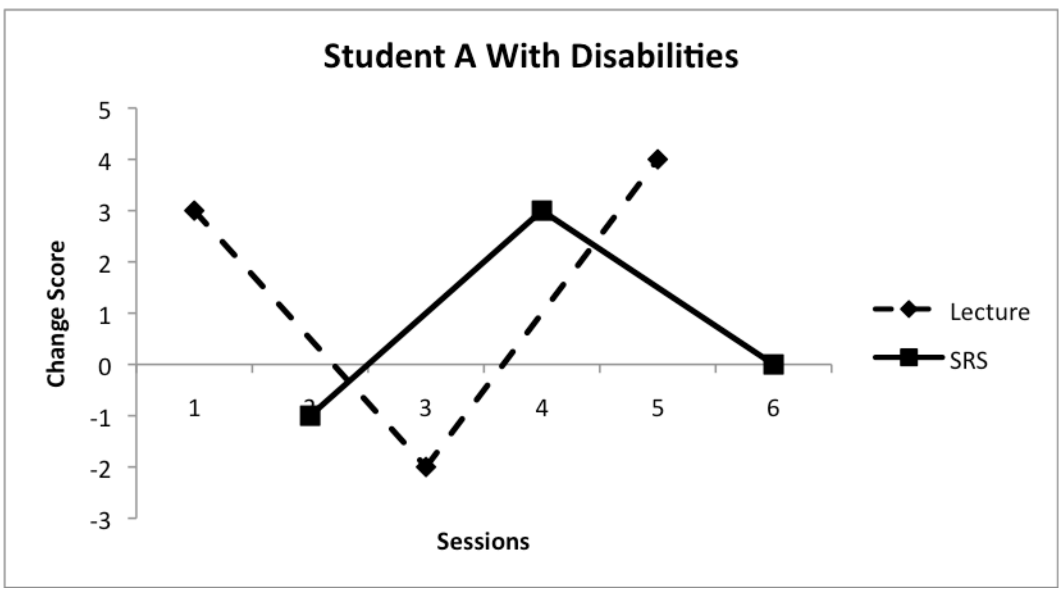

Figure 4. Change scores by intervention. This figure illustrates lecture versus SRS for Student A with disabilities.

These data indicated that there was not a notable difference between the lecture and SRS condition on this student's academic performance. However, Student A's academic performance did improve during three of the six intervention sessions (2 lecture sessions and 1 SRS session). This indicated that both interventions were successful in improving this student's academic performance. Whether this improvement was significant should be determined by the educator and the student himself rather than a statistical test. However, it should be noted that Student A's results were similar to the majority of the inclusive class results during both the lecture and SRS condition.

Student B. The results for Student B with disabilities are displayed in Figure 5. The data paths for both the lecture and SRS conditions were variable. Due to this variability, experimental control was not established. The lecture condition did not indicate a clear trend. Although the SRS condition was increasing, a trend was not established due to the limited number of data points obtained for that intervention condition. During the lecture condition, Student B's change scores from pretest to posttest ranged from 0 to 3, and the change scores ranged from -1 to 2 in the SRS condition. The highest change score from pretest to posttest was 3 correct answers gained which occurred in the lecture condition. The lowest change score from pretest to posttest occurred in the SRS condition with the loss of 1 correct answer.

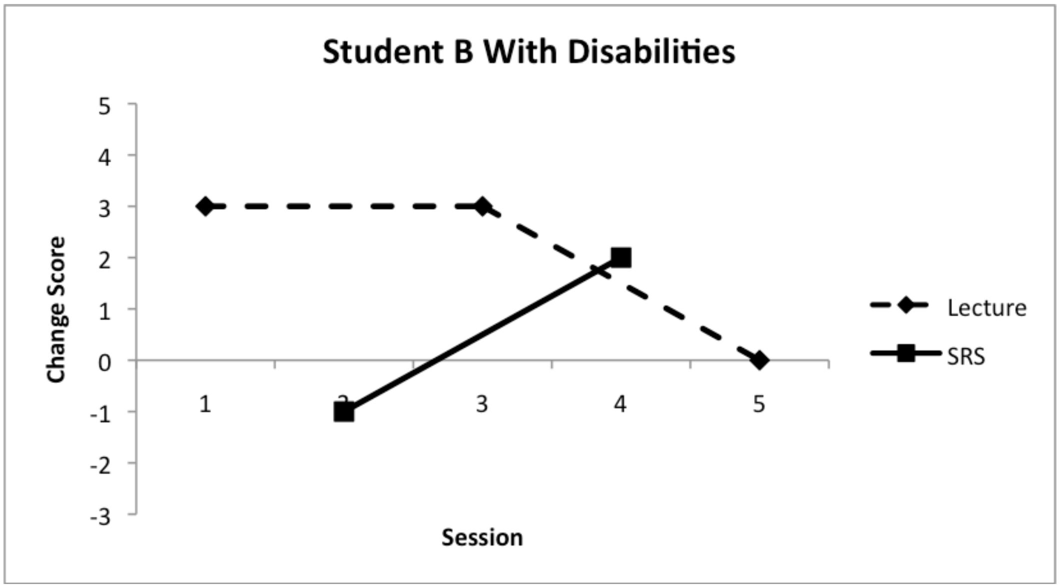

Figure 5. Change scores by intervention. This figure illustrates lecture versus SRS for Student B with disabilities.

These data indicated that there was not a noteworthy difference between the lecture and SRS condition on the academic performance for Student B. However, the student's academic performance increased during three of the five sessions (2 lecture sessions and 1 SRS session). This improvement provides evidence that both interventions were successful in increasing this student's academic achievement. Rather than using a statistical test to determine if these interventions significantly improved the academic performance of Student B, the data analysis was left up to the teacher and the student himself. However it should be noted that Student B's results fell within the same range for both the lecture and the SRS condition as the majority of the students without disabilities in the inclusive class.

Clear experimental control in neither the lecture nor the SRS condition was established for the participating students with disabilities. Both students showed improvement in their academic achievement scores during the SRS condition occasionally. However, they earned the highest change scores from pretest to posttest in the lecture condition. In conclusion based on these results, it remains unclear which instructional method (lecture or SRS) was most effective for students with disabilities.

Social Validity

The purpose of gathering social validity data was to rate the students' perceptions of the student response system intervention in the classroom, which were measured by administering a four question social validity questionnaire via the student response system upon the completion all the intervention conditions. The questions were presented using a 5-point Likert Scale which was as follows 1) "strongly disagree", 2) "disagree", 3) "neither agree nor disagree", 4) "agree" and 5) "strongly agree". The social validity results for both the non-inclusive and inclusive classes are presented in Table 10.

Table 10

Means for Social Validity Scores by Class (Non-inclusion vs. Inclusion)

	Non-inclusive	Inclusive
Question	M	M
1. "I enjoyed using the clickers during my physical science class."	3.96	4.07
2. "I feel that I was more focused on the material during the lectures in which I used a clicker."	3.89	3.79
3. "I feel my quiz scores were higher following the lectures that I used a clicker."	4.11	4.07
4. "I would recommend using clickers for this class in the future."	4.21	4.07

The results from Table 10 showed that students in both the non-inclusive and inclusive class rated the student response systems or clickers as enjoyable (Non-inclusive M= 3.96 and Inclusive *M* = 4.07). The data also revealed that the students in both classes felt more focused on the material during the sessions in which the student response systems or clicker was used (Non-inclusive *M* = 3.89 and Inclusive *M* = 3.79). The students' also perceived their quiz scores to be higher following the lectures in which they used clickers (Non-inclusive *M* = 4.11 and Inclusive 4.07). Finally, students from both the non-inclusive and inclusive class would recommend clickers for the class in the future (Non-inclusive *M* = 4.21 and Inclusive *M* = 4.07).

CHAPTER 5: Discussion

The purpose of this chapter is to interpret and explain the results of the current study, which was designed to evaluate two methods of instruction (lecture and lecture plus student response system) on students' academic achievement in a non-inclusive class and an inclusive class. The same instructional methods were also examined specifically for two students diagnosed with learning disabilities within the inclusive class. The discussion concentrates on how these findings add to the current research base and how these findings may influence educational practices. Next, limitations and ideas for future research are discussed. Finally based on the findings of the present study, this chapter closes with general remarks and conclusions.

Research Question 1

In this study, the first research question (RQ1) sought to identify the most effective instructional method (lecture or lecture plus SRS) on students' academic achievement in a non-inclusive classroom. The researcher attempted to address this research question by alternating the two treatment conditions or independent variables (lecture and SRS) across sessions. Academic achievement, the dependent variable, was measured by administering a pretest prior to intervention and posttest following intervention.

The researcher hypothesized that the lecture plus student response intervention would be the most successful in increasing students' academic performance in the non-inclusive classroom. This hypothesis was based on the following literature. First, the researcher identified substantial number of studies that support active learning rather than passive learning approaches to academic instruction (Butler, Phillmann, & Smart, 2001;

Yoder & Hochevar, 2005). Student response systems are considered an active learning strategy. Second, a significant number of studies in the literature have demonstrated student response systems as effective methods of instruction to increase students' academic achievement (Bullock et al, 2002; Kennedy & Cutts, 2005; Paschal, 2002; Poulis et al., 1998; Reay et al., 2005). Third when developing this hypothesis, a recent literature review of student response systems conducted by Fies and Marshall (2006) was considered. This literature review supported the notions that student response systems are generally an accepted practice and an effective method of instruction in the classroom. Finally, the researcher considered a group of studies that directly compared lecture and lecture plus student response systems, which revealed lecture plus student response systems as the superior method of instruction when developing this hypothesis (Morling et al., 2008; Poirier & Feldman, 2007; Slain et al., 2004; Sokolove et al., 2011).

The results for the first research question (RQ1) showed differential effects between passive lecture and active lecture using a student repose system in the non-inclusive class. The results showed that both lecture and lecture plus student response system interventions were effective in increasing students' academic achievement. However, the results revealed that the lecture plus student reponse system intervention was more effective than the lecture only intervention in increasing the students' academic achievement in the non-inclusive class. These results coincide with the overwhelming support for active learning rather than passive learning pedagogies as well as the literature in support of student response systems as a superior instructional method. Based on the results described above for the first research question, the researcher's hypothesis was accepted.

Research Question 2

The second research question (RQ2) in the present study aimed to expand the literature by identifying the most effective instructional method (lecture or SRS) on students' academic achievement in an inclusive classroom. The researcher utilized the same procedures to address this research question as used in RQ1. Again, two treatment conditions (lecture and SRS) were alternated across sessions and academic achievement was measured by administering a pretest and a posttest.

Although no studies were identified by the researcher in which student response systems were utilized with students diagnosed with disabilities, the researcher hypothesized that the lecture plus student response system condition would be more effective in improving students' academic performance than the lecture only condition. This hypothesis was based on the literature that describes learning as universal (Catania, 1998) along with previous studies that used other active learning strategies to improve performance in students with special needs. Some examples of successful active learning strategies discussed in these studies include choral responding (Kamps et al., 1994), response cards (Davis & O'Neill, 2004), and guided notes (Lazarus, 1991).

The results revealed that both lecture and lecture plus student response system interventions were effective in increasing students' academic achievement in the inclusive class. However, the lecture intervention was more effective than the lecture plus student response system intervention in increasing student performance. These results are supported by the copious amounts of literature in favor of student resposne systems as effective methods of increasing academic performance even though those studies were not conducted with students diagnosed with disaiblities (Bullock et al, 2002; Kennedy & Cutts, 2005; Paschal, 2002; Poulis et al., 1998; Reay et al., 2005).

In the present study, the students in the inclusive class did not perform better in the lecture plus student response system condition when directly compared to the lecture condition. These findings do not coincide with the literature that found when directly comparing lecture to lecture plus student response systems students' learning improved; however these studies were not conducted with students diagnosed with special needs (Morling et al., 2008; Poirier & Feldman, 2007; Slain et al., 2004; Sokolove et al., 2011). These results are also contradictory to the overwhelming support of active learning as a superior pedagogy (Butler et al., 2001; Yoder & Hochevar, 2005) as well as a number of studies that specifically support other active approaches to learning as superior when utilized with students diagnosed with learning disabilities (Davis & O'Neill, 2004; Kamps et al., 1994; Lazarus, 1991).

Based on the results of the second research question, the lecture plus student response system was not a superior method of instruction in the inclusive classroom, thus the researcher's hypothesis was rejected.

Research Question 3

In the present study, the purpose of the third research question (RQ3) was to compare two instructional interventions (lecture and SRS) across the two classrooms (non-inclusive and inclusive). The researcher attempted to address this research question by conducting a comparative analysis of the data collected during RQ1 and RQ2.

The researcher hypothesized that the lecture plus student response system instructional method would be equally effective on increasing students' academic performance in both the non-inclusive and the inclusive class. This hypothesis was based on the literature cited for both the first and second research question that supported active approaches to learning for students with and without disabilities (Butler et al; Davis & O'Neill, 2004; Fies & Marshall, 2006; Kamps et al., 1994; Lazarsus, 1991; Yoder & Hochevar, 2005). This hypothesis was also based on the literature that supports the effectiveness of student response systems as a valuable instructional method to increase students' academic performance (Bullock et al, 2002; Kennedy & Cutts, 2005; Paschal, 2002; Poulis et al., 1998; Reay et al., 2005).

The results for the third research question (RQ3) were variable. Both instructional strategies were successful in increasing the students' academic achievement. The non-inclusive class showed higher academic achievement in the lecture plus student response system condition. The inclusive class performed better or showed higher levels of academic achievement in the lecture only condition. Although the present study did report improvement in both the lecture and lecture plus student response systems interventions for both classes, the variability between interventions and classes is supported by a groups of studies that are in favor of student response systems (Bullock et al, 2002; Kennedy & Cutts, 2005; Paschal, 2002; Poulis et al., 1998; Reay et al., 2005) as a well as the cluster of studies that did not report noted increases in academic responding when utilizing a student response system as a superior instructional strategy (Judson & Sawada, 2002; Lasry & Findlay, 2007; Martyn, 2007; Stowell & Nelson, 2007). Based on the mixed results of the third research question, the researcher's hypothesis was rejected.

Research Question 4

The fourth research question (RQ4) in the current study was designed to add to the literature base by identifying the most effective instructional method (lecture or SRS) to increase academic achievement for students' with disabilities. The students with disabilities for this study were included in the inclusive classroom. Thus, the same experimental design and procedures were used to address this research question as used in RQ1 and RQ2.

The researcher hypothesized that the lecture plus student response systems condition would be the most effective intervention in increasing the students with disabilities' academic achievement even though no studies were known that examined this technology with students diagnosed with disabilities. This hypothesis was based on the same literature used to justify the hypothesis for RQ2. Learning is considered universal (Catania, 1998), and several other active learning strategies have been proven effective for students with disabilities (Davis & O'Neill, 2004; Kamps et al., 1994; Lazarsus, 1991)

The researcher separately analyzed the results for each of the students diagnosed with disabilities in the inclusive class setting. The results indicated that the student's learning did improve during the lecture condition and the lecture plus student response system on occasion. But due to the inconsistent and variable data, no differential effects between the two instructional methods for Student A or Student B with disabilities were evident.

Although the following studies were not conducted with students diagnosed with disabilities, the present study's findings do coincide with the abundant amounts of literature supporting the use of student response systems to increase academic performance (Bullock et al, 2002; Kennedy & Cutts, 2005; Paschal, 2002; Poulis et al., 1998; Reay et al., 2005). These findings are also supported by literature that demonstrated improvement in academic achievement for students with disabilities when utilizing active approaches to learning (Davis & O'Neill, 2004; Kamps et al., 1994; Lazarsus, 1991). Since the results for the students with disabilities were variable, the findings are also supported by a small number of studies identified by the researcher in which favorable results for students without disabilities academic achievement did not consistently improve when using student response systems (Ewing, 2006; Lasry & Findlay, 2007; Martyn, 2007; Stowell & Nelson, 2007).

The lack of differential effects noted between lecture and lecture plus student response systems for students with disabilities are inconsistent with the literature that found that active approaches to learning were superior to passive approaches to instruction (Butler et al., 2001; Yoder & Hochevar, 2005). Also, the results of the present study do not coincide with the findings in the literature based on students without disabilities in a non-inclusive classroom in which lecture was directly compared to lecture plus student response systems. These studies found lecture plus student response systems to be more effective in increasing academic achievement than the lecture condition (Morling et. al., 2008; Poirier & Feldman, 2007; Slain et al., 2004; Sokolove et al., 2011). Based on the inconsistent results reported for both students with disabilities, the researcher's hypothesis was rejected.

Practical Implications

Schools continue to face the challenge of identifying the most effective form of technology to be utilized in the classroom for each student. Technology is continuously changing at a rapid pace, which often proves to be a challenge for educators who are trying to identify and obtain the most effective technologies. The researcher identified several advantages and disadvantages concerning the student response system technology that might be beneficial in the decision-making process school systems face when considering investing in this equipment.

Disadvantages of student response systems identified during this study. One disadvantage noted was both the teacher and the researcher found the development of the PowerPoint® lecture through the SRS technology very time consuming. The interface between PowerPoint® and the student response system proved very difficult to sync. In fact, all PowerPoint slides had to be reentered by hand by the researcher. Another disadvantage to using SRS technology was that the data were not automatically imported into the teacher's online grade book.

Technological mishaps were another disadvantage related to the SRS technology. During the lecture plus SRS intervention, the sensors, which recorded and sent the information from the student's clicker to the teacher's computer often malfunctioned by failing to pick up the student responses. This failure was evident when the clicker number on the response tracker at bottom of the PowerPoint® slide did not light up after the student entered his or her answer. There were several solutions attempted to resolve this issue. The solutions included: interrupting the lecture plus SRS intervention to reset the clickers, simply moving the student closer to the receiver, or programming a new clicker. With the exception of one instance, the previously mentioned solutions were successful in alleviating the problem. Due to the technological issues, instructional time was taken away from the students while attempting to resolve the problem. During the pause, inappropriate classroom behavior took place such as small talk and the students leaving their seats, which resulted in distractions. The final disadvantage of the SRS technology noted during the current study was the teacher had to devote time to ensure the students read the questions, were not merely guessing, and were not cheating off of other students.

Advantages of the student response systems identified during this study. First an active learning pedagogy was utilized by offering response opportunities throughout the lecture plus SRS condition. Second, the student response system allowed every student to respond as an anonymous participant to every question proposed. Third, an unforeseen advantage arose when the students began to encourage and congratulate one another when the bar graphs and correct answers were displayed on the screen. An essence of teamwork and a group mentality was created by the students and noticed by the teacher and researcher. A fourth advantage was the immediate feedback provided to the teacher through the student response system, which displayed whether or not the students were mastering the material. Given the massive influence that technology has on today's society, the student response systems acted as an extension of that technology into the classroom. A final advantage of this system was the students seemed to enjoy using the SRS.

Influence on Educational Practices

Due to the variable results identified in this study, it is important for school systems to be informed of the possibility of improvement with SRS use, as well as the possibility of no significant change in learning, when utilizing SRS technology. Although the students seemed to enjoy using the SRS, their learning was not always enhanced. Current educational practices of incorporating student response systems into the non-inclusive classroom should continue since the results of this study are consistent with the general conclusions in the literature concerning the effectiveness of student response systems.

On the contrary in the inclusive class, this study found the SRS was effective in increasing academic performance on occasion but was not as effective as lecture alone. The differential effects in learning that were noted when the SRS was used in the inclusive classroom as opposed to lecture may impact the instructional methods teachers choose to use with students in an inclusive class as well as students with disabilities. Based on these findings, it is imperative to implement individual testing to determine if SRS technology is an appropriate learning technique for each student in each subject. By determining the individual student's capability to learn using the SRS, a decision can be reached on whether the benefits of that system warrant the amount time, intensive effort and finical investment involved in implementing it.

Limitations

Despite the current findings that support the use of student response systems as an instructional method to increase students' academic achievement in the non-inclusive class, as well as the potential to increase students' achievement in the inclusive class and for students with disabilities, this study was not without limitations. One limitation identified by the researcher was the intervention conditions (lecture and SRS) were not identical. During the SRS condition, 12 interactive questions were incorporated into the PowerPoint® lecture. Then, the students throughout the lecture used the student response system or clicker to enter their answers for each question. After the allotted time interval passed for each interactive question, a bar graph that the teacher reviewed was displayed which provided the students with feedback. If the conditions had been identical as intended by the researcher, the same questions would have been proposed in the lecture condition PowerPoint® as well. The students would not have been asked to answer the questions but information would have been presented.

A second limitation identified was on one occasion during the study, the teacher was prompting the students as to which information was important and needed to be written down. To minimize this problem, the researcher instructed the teacher to refrain from this practice during the next day's sessions. The teacher was able to abstain from this practice for the remainder of the sessions.

Another potential limitation was the students' interest might have potentially been limited due the lack of a positive or negative consequence for participating in this study. Although the students knew their responses were being tracked, they were all made aware they would not be receiving a grade for their answers.

The overall sample size of this study was a limitation as well as the small number of participating students with disabilities. The original number of students with intellectual disabilities was three; however, one student moved between planning and the onset of the study. Attrition was another weakness of this study due to unforeseen absences including: illness, in school suspensions, out of school suspensions, and others.

A confounding variable for this study was that all of the participants had prior experience with the SRS technology. The possibility of the students' success due to previous exposure to the SRS was not a measurable limitation by the researcher. Another potential confounding variable was the use of an alternating treatment design, because the information presented to the students changed each day. Thus, the researcher was unable to determine if differential effects noted were correlated with the difficulty of the material being taught during each session.

Future Research

Future research should further investigate the relationship between the use of student response system technology and students with intellectual disabilities. This research should include a wider spectrum of disabilities and ages. Future researchers may want to utilize a larger sample size of students with disabilities, as well as increase the number of participating teachers.

Future researchers may want to examine the relationship between gender and SRS technology. The groups in this study were not evenly matched based on gender. The non-inclusive class had more males than females, and this present study found that SRS technology was more effective in the non-inclusive classroom. A correlation between gender and SRS technology may exist. However, the present study did not analyze this potential relationship. Also, the present study noted a difference of age among the participants in the non-inclusive and inclusive class. Based on the differential effects identified in this study for each classroom, this is an area the researcher feels would benefit from further testing.

The researcher believes it would be valuable to examine the types of questions interjected into the lecture. The number of questions used and the amount of time between each question might also yield beneficial information. Future studies should address the effectiveness of immediately reteaching a subject if the SRS data reveals a below mastery response from the classroom.

During this study, the researcher observed the participating teacher having to allocate more time to classroom management when the SRS was being used. It would be valuable for future research to collect maladaptive behavior data simultaneously along with the SRS data. This information would be useful in determining the effects of this technology, if any, on students' maladaptive behavior.

Conclusion

Before school systems make a substantial financial investment in this technology, it is crucial that student response systems show clear and consistent benefits in students' academic achievement. The main conclusion taken from the results of this study is that electronic student response systems are a developing technology that shows potential for improving students' academic achievement in the non-inclusive classroom. However, further research regarding the utilization of student response systems in inclusive classrooms, and with students with disabilities is necessary.

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Appendix A: Teacher Consent Form

THE UNIVERSITY OF MEMPHIS

Instruction & Curriculum Leadership
College of Education

404 Ball Hall
Memphis, Tennessee
38152-3570

Office: 901.678.2365
Fax: 901.678.3881

Dear Teacher:

The following information is provided to inform you about the research project entitled: "*How Can We Make Teaching More Effective? Lecture versus Sttudent Response Systems"* and your participation in it. Please read this form carefully and feel free to ask any questions you may have about this study and the information given below. You will be given an opportunity to ask questions, and your questions will be answered. Also, you will be given a copy of this consent form.

Your participation in this research study is voluntary. You are also free to withdraw from this study at any time. In the event new information becomes available that may affect the risks or benefits associated with this research study or your willingness to participate in it, you will be notified so that you can make an informed decision whether or not to continue your participation in this study.

The purpose of the study is to determine if the use of classroom clickers are effective in student learning throughout a lecture. The study will also investigate the effect of clickers on posttest scores of students with disabilities in an inclusive classroom.

This study will take place during both of your inclusive physical science classes if your informed consent is obtained. All of your students will be included in the study if his or her legal guardians provided written informed consent. If no informed consent is provided, these students will NOT be asked to participate in the study. This study will NOT interfere with your student's learning objectives as you, the classroom teacher, have previously determined. If you agree to participate in this study, you will be asked to take part in both a planning phase as well as an implementation phase.

There are not costs associated with this study nor is there compensation for participation.

With every study there are some discomforts, inconveniences, and/or risks that can be reasonably expected as a result of participation in this study. For example, during this study, you may feel some anxiety surrounding the implementation days due to the researchers presence in the classroom. Finally, you may experience frustration due to technical difficulties with the technology, but the researcher is well prepared to assist with any issues.

Also, with any study there are anticipated benefits. In this study, your student will be provided with an opportunity to answer sample test questions and receive feedback prior to the testing, which will be for a grade. The pretest, the posttest and the interactive questions will provide your student's a chance to practice answering questions during a timed test. This study also has the potential to identify a way to improve your instruction and your students learning.

All efforts, within the limits allowed by law, will be made to keep the personal information in your research record private but total privacy cannot be promised. Your information may be shared with U of M or the government, such as the University of Memphis University Institutional Review Board, Federal Government Office for Human Research Protections, Dyer County High School, if you or someone else is in danger or if we are required to do so by law.

If you should have any questions about this research study or possible injury, please feel free to contact Jenny Hayes (jahayes@memphis.edu) or my Faculty Advisor**,** Dr. Laura Casey (lpcasey@memphis.edu) questions regarding the research subjects' rights; the Chair of the Institutional Review Board for the Protection of Human Subjects should be contacted at 678-2533. **For additional information about giving consent or your rights as a participant in this study, please feel free to contact the IRB at 901-678-2533 or email irb@memphis.edu.**

Please read the following prior to agreeing to participate in the study.

> **I have read this informed consent document and the material contained in it has been explained to me verbally. I understand each part of the document, all my questions have been answered, and I freely and voluntarily choose to participate in this study.**

____________________ ____

Date Signature of Teacher

____

Printed Name of Teacher

Consent obtained by:

____________________ ____

Date Signature

____

Printed Name and Title

Appendix B: Guardian Consent Form

THE UNIVERSITY OF MEMPHIS

Instruction & Curriculum Leadership
College of Education

404 Ball Hall
Memphis, Tennessee 38152-3570

Office: 901.678.2365
Fax: 901.678.3881

Classroom Teacher:

Principal Investigator: Jenny Hayes, MS BCBA
Study Title: *How Can We Make Teaching More Effective? Lecture versus Student Response Systems*
Institution: University of Memphis

Name of participant: ____ Age: __________

The following information is provided to inform you about the research project and your child's participation in it. Please read this form carefully and feel free to ask any questions you may have about this study and the information given below. You will be given an opportunity to ask questions, and your questions will be answered. Also, you will be given a copy of this consent form.

Your child's participation in this research study is voluntary. He or she is also free to withdraw from this study at any time. In the event new information becomes available that may affect the risks or benefits associated with this research study or your willingness to participate in it, you will be notified so that you can make an informed decision whether or not to continue your participation in this study.

For additional information about giving consent or your rights as a participant in this study, please feel free to contact IRB.

1. **Purpose of the study:**
   Your student is being asked to participate in a research study because your student's classroom teacher is currently using an electronic response system (clickers) during classroom instruction. These clickers are similar to the remote controls used on the popular television show *Who Wants to be a Millionaire.* The clickers allow the teacher to quickly poll student responses during instruction time. The clickers provide immediate feedback to the students and teacher on the material being taught. The current study will help to determine if the use of classroom clickers are effective in student learning throughout a lecture.

2. **Description of procedures to be followed and approximate duration of the study:**
   This study will take place during your student's physical science class. It will NOT interfere with your student's learning objectives as scheduled by the classroom teacher. Your student will be asked during two class periods to respond to multiple-choice questions based on the learning objectives throughout the regularly scheduled lecture using a clicker. Also, your student will be asked to complete a quiz before and after each lecture using the clickers. These quizzes will NOT count toward his or her grade. The quizzes are just a way to determine if the clickers helped improved your student's learning. The duration of this study is 4 physical science class periods.

   Prior to the study, your student will be asked to anonymously complete a demographic questionnaire and a brief clicker training. The survey will include age, grade level, ethnicity, and gender. Upon the completion of the study, your student will be asked to complete a satisfaction questionnaire. An example question from this survey is "Did you enjoy using clickers during your physical science class?"

   Day 1: Your child will complete a quiz before and after his or her regularly scheduled lecture. He or she will use a clicker throughout the lecture. The questions on the quiz will cover material relevant to the current lesson.

   Day 2: Your child will complete a quiz before and after his or her regularly scheduled lecture. Clickers will NOT be used during the lecture.

   Day 3: Will be identical to Day 1. However, new material will be covered.

   Day 4: Will be identical to Day 2. Again, new material will be covered.

   Remember that your student is already using clickers in his or her classroom. This study simply introduces a quiz before and after each lecture as well as interactive clicker questions during his or her teacher's lecture.

3. **Expected costs:**
   There are not costs associated with this study.

4. **Description of the discomforts, inconveniences, and/or possible risks that can be reasonably expected as a result of participation in this study:**
   Your student may experience anxiety surrounding the quizzes, but it will be explained to each student that these quizzes will NOT affect his or her grade in the class. You student may experience technical difficulties with the technology, but the classroom is teacher is well prepared to assist with any issues.

5. **Compensation in case of study-related injury:**

U of M does not have a fund set aside for compensation in the case of study related injury. The researcher does not feel that injuries are unlikely for this study.

6. **Anticipated benefits from this study:**
   This study will help determine how your child's classroom teacher uses clickers during academic instruction to improve his or her learning. This study should also increase your child's participation throughout the class period. This study will provide your student with an opportunity to answer sample test questions and receive feedback prior to the test give by classroom teacher, which will be for a grade. (This test and grade will NOT be a part of this study). Finally, the pretest, the posttest and the interactive questions will provide your student a chance to practice answering questions during a timed test, which is similar to the standardized test, ACT, your student will be taking.

7. **Alternative treatments available:**
   The traditional lecture method is the alternate treatment that is currently available.

8. **Compensation for participation:**
   There will be no compensation provided for participation in this study.

9. **Circumstances under which the Principal Investigator may withdraw you from study participation:**
   If your consent is obtained, the researcher will not withdraw your student from the study under any circumstance.

10. **What happens if you choose to withdraw from study participation:**
    If you choose to withdraw your student from the study, he or she will not be asked use the clickers during lecture. However, he or she will still participate in the lecture as expected by the classroom teacher.

11. **Contact Information.**
    If you should have any questions about this research study or possibly injury, please feel free to contact Jenny Hayes at (jahayes@memphis.edu) or my Faculty Advisor**,** Dr. Laura Casey at (lpcasey@memphis.edu).

12. **Confidentiality.** All efforts, within the limits allowed by, will be made to keep the personal information in your child's research record private but total privacy cannot be promised. Your information may be shared with U of M or the government, such as the University of Memphis Institutional Review Board, Federal Government's Office for Human Research Protections, *if* you or someone else is in danger or if we are required to do so by law. Your child's name will not be used during this study. Only number will identify his or her clicker, and this number will not be available to the researcher.

14. **STATEMENT BY PERSON AGREEING TO PARTICIPATE IN THIS**

STUDY

I have read this informed consent document and the material contained in it has been explained to me verbally. I understand each part of the document, all my questions have been answered, and I give permission for my child to participate in the study.

Date Signature Student Printed

Name

Consent obtained by:

Date Signature

Printed Name and Title

Appendix C: Student Assent Form

THE UNIVERSITY OF MEMPHIS®

Instruction & Curriculum Leadership
College of Education

404 Ball Hall
Memphis, Tennessee 38152-3570

Office: 901.678.2365
Fax: 901.678.3881

www.memphis.edu

Dear Student:

You are being asked to take part in a study entitled *How Can We Make Teaching More Effective? Lecture versus Student Response Systems* because your physical science class uses clickers and the research is investigating the effects of clickers vs. no clickers in terms of retention of the material taught during the science classes.

During this study, you will be asked to answer some questions before, during, and after each of your physical science lectures. The questions during the lectures will involve you using your clicker. Your answers you will NOT count toward your class grade. This study will last one week.

It is important to understand that you do **NOT** have to be in this study. Also, if you do agree and then change your mind, you can stop at any time by simply telling your teacher that you no longer want to participate.

All efforts, within reason, will be made to keep the data in your research and your name will not be used. In rare cases, your data may be shared. For example, if you or someone else is in danger or if we have to do so by law.

This research may help improve your learning in your physical science class. By taking part in this study, you could help other students' learning too. You will help the researchers to decide if clickers are effective in the classroom. Finally, you will help your teacher to find different ways to teach you and other students in the future.

If you choose not to participate, you can still attend your regular physical science. However, you will not answer any of the questions before, during, or after the lectures.

If you have any questions, you can talk to or email the researcher, Jenny Hayes (jahayes@memphis.edu).

Thank you,

Jenny

______________ ____

Date Signature of Student Printed Name

Consent obtained by:

____

Signature Printed Name and Title

Appendix D: School Consent Form

THE UNIVERSITY OF MEMPHIS

Instruction & Curriculum
Leadership
College of Education

404 Ball Hall
Memphis, Tennessee
38152-3570

Office: 901.678.2365
Fax: 901.678.3881

To the University of Memphis Institutional Review Board:

I am writing to indicate my support and the support of ___________High School in participating in a research study conducted by primary investigator Jenny Hayes and co-investigator Dr. Laura Casey. The procedures and protocols of the research study entitled *How Can We Make Teaching More Effective? Lecture versus Student Response Systems* have been explained to me and I have deemed them acceptable from the standpoint of my school. I understand that at least one of our teachers will be involved in the study, as will at least one of our students. In addition, I understand that Jenny Hayes or Laura Casey may be involved.

It has been explained that the study will be conducted as early as October 17, 2011 (pending IRB approval) and that the study should last no longer than 1 week (2 class periods per day).

Again, I would like to indicate my support for this research and the support of Dyer County High School. I believe the study may benefit our students and our teachers.

Sincerely,

Appendix E: Lectures

Lecture Plus SRS: Session 1

What is Matter?
McLaughlin, C.W., Thompson, M. T., & Zike, D.(2010). *Tennessee Physical Science. McGraw-Hill, Inc.*

Matter

- Anything that has mass and takes up space.
- Everything is made of matter.
- Matter is made up of atoms.
- Atoms =Smallest particle that has the properties of that element

Graphic Organizer

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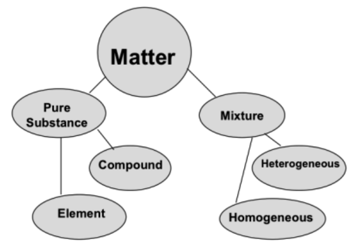


Question 1: What is the smallest particle that has properties of that element?

1. Atom
2. Compound
3. Element
4. Mixture

Question 2: Which of the following is made up of matter?

1. Brick
2. Chair
3. Desk
4. All of the above

Pure Substances

- Materials are made up of a pure substance or a mixture of pure substances.
- A pure substance, or simply a substance, is a type of matter with a fixed composition.
- A substance can either be an element or a compound.

Question 3: A pure substance can which of the following?

1. Element
2. Compound
3. Colloid
4. Both 1 and 2

Elements

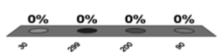
- All substances are built from atoms. If all the atoms in the substance have the same identity, that substance is an element.
- The graphite in your pencil point and the cooper coating of most pennies are examples of elements.

Elements

- Elements = cannot be broken down into simpler substances.
- About 90 elements are found on Earth
- More then 20 others have been made in laboratories, but most of these are unstable and exist only for short periods of time.
- Example – sodium, chlorine, hydrogen.
- Elements are found on the periodic table.

Question 4: How many elements are found on Earth?

1. 30
2. 299
3. 200
4. 90



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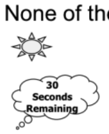
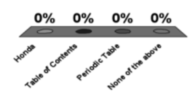
21	22	23	24	25	26	27	28	29	30										

Question 5: Where are all the elements listed?

1. Honda
2. Table of Contents
3. Periodic Table
4. None of the above





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21	22	23	24	25	26	27	28	29	30										

Compounds

- A compound is a substance in which the atoms of two or more elements are combined in a fixed proportion.
- Ex. Salt: NaCl; Hydrochloric Acid: HCl; Carbon Dioxide: CO_2 ; Potassium Chloride: KCl; Carbon Monoxide: CO

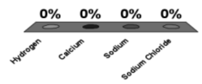
Compounds

- Can you imagine yourself putting something made from a slivery metal and a greenish yellow, poisonous gas on your food?
- Table salt is a chemical compound that fits this description. Even though it looks like white crystals and adds flavor to food, its components-sodium and chlorine- are neither white nor salty.

Question 6: Which of the following is a compound?

1. Hydrogen
2. Calcium
3. Sodium
4. Sodium Chloride

30



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21	22	23	24	25	26	27	28	29	30										

Mixtures

- Mixtures can either be homogeneous or heterogeneous.
- Homogeneous mixtures contain two or more gaseous, liquid, or solid substances blended evenly throughout.
- Another name for a homogeneous mixture is a solution
- Ex. Vinegar, soft drinks sealed in bottles.

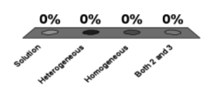
Mixtures

- A mixture, such as pizza or a soft drink, is a material made up of two or more substances that can be easily separated by physical means.

Question 7: Which of the following is a type of a mixture?

1. Solution
2. Heterogeneous
3. Homogeneous
4. Both 2 and 3

30



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Heterogeneous Mixtures

- Unlike compounds, mixtures do not always contain the same proportions of the substances that make them up.
- A mixture in which different materials can be distinguished easily is a called a heterogeneous mixture.
- These mixtures can be separated by physical means.

Heterogeneous Mixtures

- Most of the substances you come in contact with every day are heterogeneous mixtures. Some components are easy to see, like the ingredients in pizza, but others are not.
- For example, the cheese in pizza is also a mixture, but you cannot see the individual components.

Question 8: Which of the following is a heterogeneous mixture?

1. Pizza
2. Salad
3. Water
4. Both 1 and 2

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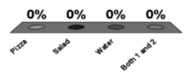

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Homogeneous Mixtures

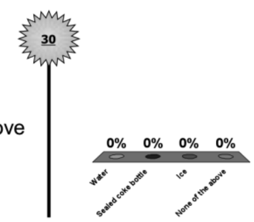
- A homogeneous mixture contains two or more gaseous, liquid, or solid substances blended evenly throughout.
- Another name for homogeneous mixtures like a cold soft drink is solution.
- A solution is a homogeneous mixture of particles so small that they cannot be seen with a microscope and will never settle to the bottom of their container.

Homogeneous Mixtures

- Soft drinks contain water, sugar, flavoring, coloring, and carbon dioxide gas.
- Soft drinks in sealed bottles are examples of homogeneous mixtures.

Question 9:Which of the following is a homogeneous mixture?

1. Water
2. Sealed coke bottle
3. Ice
4. None of the above



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Colloids

- Milk is an example of a specific kind of mixture called a colloid.
- A colloid is a type of mixture with particles that are larger than those in solutions but not heavy enough to settle out.

Detecting Colloids

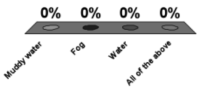
- One way to distinguish a colloid from a solution is by it's appearance.
- Fog appears white because its particles are large enough to scatter light.
- Sometimes it is not so obvious that a liquid is a colloid
- You can tell for certain if a liquid is a colloid by passing a beam of light through it.

Detecting Colloids

- A light beam is invisible as it passes through a solution, but can be seen readily as it passes through a colloid. This occurs because the particles in the colloid are large enough to scatter light, but those in the solution are not.
- This scattering of light by colloidal particles is called Tyndall effect.

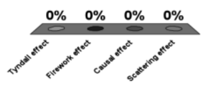
Question 10: Which of following is an example of a colloid?

1. Muddy water
2. Fog
3. Water
4. All of the above



Question 11:The scattering of light by colloidal particles is called

1. Tyndall effect
2. Firework effect
3. Causal effect
4. Scattering effect



Suspensions

- Some mixtures are neither solutions nor colloids. One example is muddy pond water.
- Pond water is a suspension, which is a heterogeneous mixture containing a liquid in which visible particles settle.

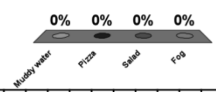
- The table summarizes the properties of different types of mixtures.

Comparing Solutions, Colloids, and Suspensions

Description	Solutions	Colloids	Suspensions
Settle upon standing?	No	No	Yes
Separate using filter paper?	No	No	Yes
Particle size	0.1-1min	1-100 nm	> 100nm
Scatter light?	No	Yes	Yes

Question 12: Which of the following is an example of a suspension?

1. Muddy water
2. Pizza
3. Salad
4. Fog



Lecture: Session 1

What is Matter?
McLaughlin, C.W., Thompson, M. T., & Zike, D.(2010). *Tennessee Physical Science. McGraw-Hill, Inc.*

Matter

- Anything that has mass and takes up space.
- Everything is made of matter.
- Matter is made up of atoms.
- Atoms =Smallest particle that has the properties of that element

Graphic Organizer

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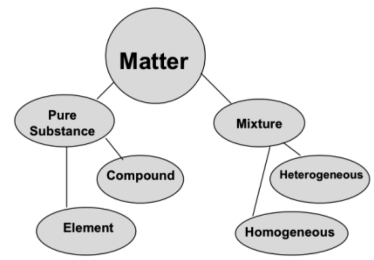

Pure Substances

- Materials are made up of a pure substance or a mixture of pure substances.
- A pure substance, or simply a substance, is a type of matter with a fixed composition.
- A substance can either be an element or a compound.

Elements

- All substances are built from atoms. If all the atoms in the substance have the same identity, that substance is an element.
- The graphite in your pencil point and the cooper coating of most pennies are examples of elements.

Elements

- Elements = cannot be broken down into simpler substances.
- About 90 elements are found on Earth
- More then 20 others have been made in laboratories, but most of these are unstable and exist only for short periods of time.
- Example – sodium, chlorine, hydrogen.
- Elements are found on the periodic table.

Compounds

- A compound is a substance in which the atoms of two or more elements are combined in a fixed proportion.
- Ex. Salt: NaCl; Hydrochloric Acid: HCl; Carbon Dioxide: CO_2 ; Potassium Chloride: KCl; Carbon Monoxide: CO

Compounds

- Can you imagine yourself putting something made from a slivery metal and a greenish yellow, poisonous gas on your food?
- Table salt is a chemical compound that fits this description. Even though it looks like white crystals and adds flavor to food, its components-sodium and chlorine- are neither white nor salty.

Mixtures

- Mixtures can either be homogeneous or heterogeneous.
- Homogeneous mixtures contain two or more gaseous, liquid, or solid substances blended evenly throughout.
- Another name for a homogeneous mixture is a solution
- Ex. Vinegar, soft drinks sealed in bottles.

Mixtures

- A mixture, such as pizza or a soft drink, is a material made up of two or more substances that can be easily separated by physical means.

Heterogeneous Mixtures

- Unlike compounds, mixtures do not always contain the same proportions of the substances that make them up.
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Lecture Plus SRS: Session 2

Properties of Matter : 15.2 Physical Properties
McLaughlin, C.W., Thompson, M. T., & Zike, D.(2010). *Tennessee Physical Science. McGraw-Hill, Inc.*

Physical Properties

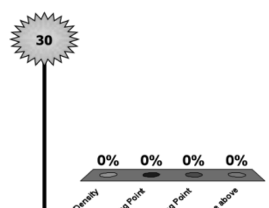
- Any characteristic of a material that you can observe without changing the identity of the substances that make up the material is a physical property.
- Examples of physical properties are color, shape, size, density, melting point, and boiling point.

Appearance

- How would you describe a tennis ball? You could begin by describing its shape, color, and state of matter.
- You can measure some physical properties, too. For instance, you could measure the diameter of the ball.

Question 1: Which of the following is an example of a physical property?

1. Density
2. Melting Point
3. Boiling Point
4. All of the above



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Question 2: The shape of an apple is a ______?

1. Chemical Change
2. Chemical Property
3. Physical Change
4. Physical Property

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
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Behavior

- Some physical properties describe the behavior of a material or a substance.
- Attraction to a magnet is a physical property of the substance iron.
- Every substance has a specific combination of physical properties that make it useful for certain tasks.

Using Physical Properties to Separate

- The best way to separate substances depends on their physical properties.
- Size is one physical property often used to separate substances.

Physical Properties

- Any characteristic of a material that you can observe without changing the identity of the substances that make up the material is a physical property.
- Examples of physical properties are color, shape, size, density, melting point, and boiling point.

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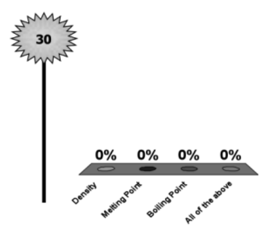

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2. Chemical Property
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1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
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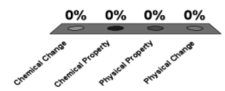
Using Physical Properties to Separate

- The best way to separate substances depends on their physical properties.
- Size is one physical property often used to separate substances.

Question 3: The best way to separate substances depends on______?

1. Chemical Change
2. Chemical Property
3. Physical Property
4. Physical Change



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Using Physical Properties to Separate

- Look at the mixture of iron filings and sand shown.
- You probably won't be able to sift out the iron filings because they are similar in size to the sand particles. What you can do is pass a magnet through the mixture.

Using Physical Properties to Separate

- The magnet attracts only the iron filings and pulls them from the sand. This is an example of how a physical property, such as magnetic attraction, can be used to separate substances in a mixture.

Physical Change

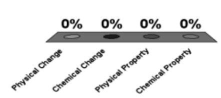
The Identity Remains the Same

A change in size, shape, or state of matter is called a **physical change.**

- These changes might involve energy changes, but the kind of substance—the identity of the element or compound—does not change.

Question 4: Chopping wood is an example of _____?

1. Physical Change
2. Chemical Change
3. Physical Property
4. Chemical Property



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The Identity Remains the Same

- Iron is a substance that can change states if it absorbs or releases enough energy—at high temperatures, it melts.
- Color changes can accompany a physical change, too.
- For example, when iron is heated it first glows red. Then, if it is heated to a higher temperature, it turns white.

Using Physical Change to Separate

- Many such areas that lie close to the sea obtain drinking water by using physical properties of water to separate it from the salt.
- One of these methods, which uses the property of boiling point, is a type of distillation.

Question 5: Which of the following is an example of a physical property used during distillation?

1. Boiling Point
2. Melting Point
3. Freezing Point
4. None of the above

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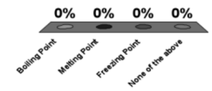

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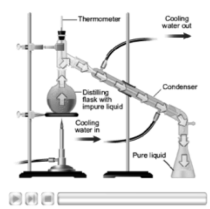
Distillation

- The process for separating substances in a mixture by evaporating a liquid and recondensing its vapor is **distillation**.
- It usually is done in the laboratory using an apparatus similar to that shown.

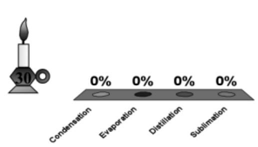


Distillation

- Two liquids having different boiling points can be separated in a similar way.
- The mixture is heated slowly until it begins to boil.
- Vapors of the liquid with the lowest boiling point form first and are condensed and collected. Then, the temperature is increased until the second liquid boils, condenses, and is collected.

Question 6: ____ is the process for separating substances in a mixture by evaporating a liquid and recondensing its vapor.

1. Condensation
2. Evaporation
3. Distillation
4. Sublimation



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Chemical Properties and Changes

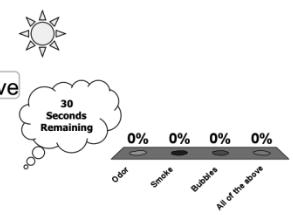
- The tendency of a substance to burn, or its flammability, is an example of a chemical property because burning produces new substances during a chemical change.
- A **chemical property** is a characteristic of a substance that indicates whether it can undergo a certain chemical change.

Detecting Chemical Change

- If you leave a pan of chili cooking unattended on the stove for too long, your nose soon tells you that something is wrong.
- This burnt odor is a clue telling you that a new substance has formed.
- Other indicators of a chemical change are smoke, odor and bubbles.

Question 7: Which of the following indicates a chemical change?

1. Odor
2. Smoke
3. Bubbles
4. All of the above



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The Identity Changes

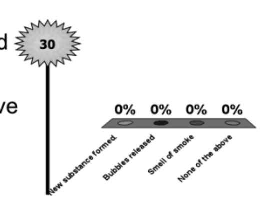
- A change of one substance to another is a **chemical change**.
- The foaming of an antacid tablet in a glass of water and the smell in the air after a thunderstorm are other signs of new substances being produced.

The Identity Changes

- Clues such as heat, cooling, or the formation of bubbles or solids in a liquid are helpful indicators that a reaction is taking place.
- However, the only sure proof is that a new substance is produced.
- The only clue that iron has changed into a new substance is the presence of rust.
- Burning and rusting are chemical changes because new substances form.

Question 8: What is the one sure way to tell if a chemical reaction has taken place?

1. New substance formed.
2. Bubbles released
3. Smell of smoke
4. None of the above



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Using Chemical Change to Separate

- One case where you might separate substances using a chemical change is in cleaning tarnished silver.
- Tarnish is a chemical reaction between silver metal and sulfur compounds in the air which results in silver sulfide.
- It can be changed back into silver using a chemical reaction.

Using Chemical Change to Separate

- You don't usually separate substances using chemical changes in the home.
- In industry and chemical laboratories, however, this kind of separation is common. For example, many metals are separated from their ores and then purified using chemical changes.

Question 9: Separating substance using chemical changes typically occurs in which of the following?

1. Home
2. Laboratory
3. School
4. All of the above

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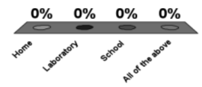

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Weathering—Chemical or Physical Change?

- The forces of nature continuously shape Earth's surface. Rocks split, deep canyons are carved out, sand dunes shift, and curious limestone formations decorate caves.
- Do you think these changes, often referred to as weathering, are physical or chemical? The answer is both.

Physical

- Large rocks can split when water seeps into small cracks, freezes, and expands.
- However, the smaller pieces of newly exposed rock still have the same properties as the original sample.
- This is a physical change.

Question 10: Weathering is an example of which of the following?

1. Chemical Change
2. Physical Change
3. Both 1 and 2
4. None of the Above.

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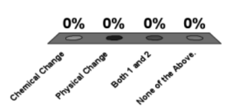

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Chemical

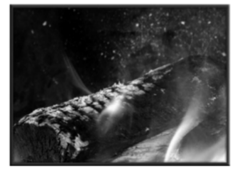
- Solid calcium carbonate, a compound found in limestone, does not dissolve easily in water.
- However, when the water is even slightly acidic, as it is when it contains some dissolved carbon dioxide, calcium carbonate reacts.
- It changes into a new substance, calcium hydrogen carbonate, which does dissolve in water.

Chemical

- A similar chemical change produces caves and the icicle shaped rock formations that often are found in them.

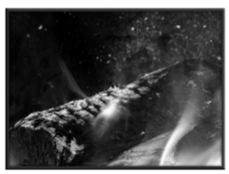
The Conservation of Mass

- Suppose you burn a large log until nothing is left but a small pile of ashes.
- At first, you might think that matter was lost during this change because the pile of ashes looks much smaller than the log did.



The Conservation of Mass

- In fact, the mass of the ashes is less than that of the log.



The Conservation of Mass

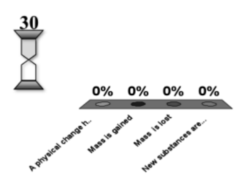
- However, suppose that you could collect all the oxygen in the air that was combined with the log during the burning and all the smoke and gases that escaped from the burning log and measure their masses, too.
- Then you would find that no mass was lost after all.

The Conservation of Mass

- Not only is no mass lost during burning, mass is not gained or lost during any chemical change.
- According to the **law of conservation of mass**, the mass of all substances that are present before a chemical change equals the mass of all the substances that remain after the change.

Question 11: When a log burns in a fire, _______.

1. A physical change has occurred.
2. Mass is gained
3. Mass is lost
4. New substances are formed



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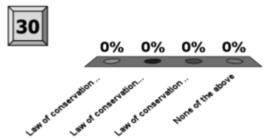
Question 12: According to the _____, the mass of all substances that are present before a chemical change equals the mass of all substances that remain after the change.

1. Law of conservation of matter
2. Law of conservation of mass
3. Law of conservation of energy
4. None of the above



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Lecture: Session 2

Properties of Matter : 15.2 Physical Properties
McLaughlin, C.W., Thompson, M. T., & Zike, D.(2010). *Tennessee Physical Science. McGraw-Hill, Inc.*

Physical Properties

- Any characteristic of a material that you can observe without changing the identity of the substances that make up the material is a physical property.
- Examples of physical properties are color, shape, size, density, melting point, and boiling point.

Appearance

- How would you describe a tennis ball? You could begin by describing its shape, color, and state of matter.
- You can measure some physical properties, too. For instance, you could measure the diameter of the ball.

Behavior

- Some physical properties describe the behavior of a material or a substance.
- Attraction to a magnet is a physical property of the substance iron.
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Using Physical Properties to Separate

- The best way to separate substances depends on their physical properties.
- Size is one physical property often used to separate substances.

Using Physical Properties to Separate

- Look at the mixture of iron filings and sand shown.
- You probably won't be able to sift out the iron filings because they are similar in size to the sand particles. What you can do is pass a magnet through the mixture.

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- These changes might involve energy changes, but the kind of substance—the identity of the element or compound—does not change.

The Identity Remains the Same

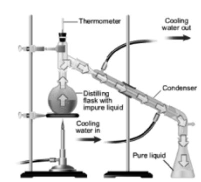
- Iron is a substance that can change states if it absorbs or releases enough energy—at high temperatures, it melts.
- Color changes can accompany a physical change, too.
- For example, when iron is heated it first glows red. Then, if it is heated to a higher temperature, it turns white.

Using Physical Change to Separate

- Many such areas that lie close to the sea obtain drinking water by using physical properties of water to separate it from the salt.
- One of these methods, which uses the property of boiling point, is a type of distillation.

Distillation

- The process for separating substances in a mixture by evaporating a liquid and recondensing its vapor is **distillation.**
- It usually is done in the laboratory using an apparatus similar to that shown.



Distillation

- Two liquids having different boiling points can be separated in a similar way.
- The mixture is heated slowly until it begins to boil.
- Vapors of the liquid with the lowest boiling point form first and are condensed and collected. Then, the temperature is increased until the second liquid boils, condenses, and is collected.

Chemical Properties and Changes

- The tendency of a substance to burn, or its flammability, is an example of a chemical property because burning produces new substances during a chemical change.
- A **chemical property** is a characteristic of a substance that indicates whether it can undergo a certain chemical change.

Detecting Chemical Change

- If you leave a pan of chili cooking unattended on the stove for too long, your nose soon tells you that something is wrong.
- This burnt odor is a clue telling you that a new substance has formed.
- Other indicators of a chemical change are smoke, odor and bubbles.

The Identity Changes

- A change of one substance to another is a **chemical change**.
- The foaming of an antacid tablet in a glass of water and the smell in the air after a thunderstorm are other signs of new substances being produced.

The Identity Changes

- Clues such as heat, cooling, or the formation of bubbles or solids in a liquid are helpful indicators that a reaction is taking place.
- However, the only sure proof is that a new substance is produced.
- The only clue that iron has changed into a new substance is the presence of rust.
- Burning and rusting are chemical changes because new substances form.

Using Chemical Change to Separate

- One case where you might separate substances using a chemical change is in cleaning tarnished silver.
- Tarnish is a chemical reaction between silver metal and sulfur compounds in the air which results in silver sulfide.
- It can be changed back into silver using a chemical reaction.

Using Chemical Change to Separate

- You don't usually separate substances using chemical changes in the home.
- In industry and chemical laboratories, however, this kind of separation is common. For example, many metals are separated from their ores and then purified using chemical changes.

Weathering—Chemical or Physical Change?

- The forces of nature continuously shape Earth's surface. Rocks split, deep canyons are carved out, sand dunes shift, and curious limestone formations decorate caves.
- Do you think these changes, often referred to as weathering, are physical or chemical? The answer is both.

Physical

- Large rocks can split when water seeps into small cracks, freezes, and expands.
- However, the smaller pieces of newly exposed rock still have the same properties as the original sample.
- This is a physical change.

Chemical

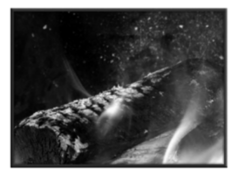
- Solid calcium carbonate, a compound found in limestone, does not dissolve easily in water.
- However, when the water is even slightly acidic, as it is when it contains some dissolved carbon dioxide, calcium carbonate reacts.
- It changes into a new substance, calcium hydrogen carbonate, which does dissolve in water.

Chemical

- A similar chemical change produces caves and the icicle shaped rock formations that often are found in them.

The Conservation of Mass

- Suppose you burn a large log until nothing is left but a small pile of ashes.
- At first, you might think that matter was lost during this change because the pile of ashes looks much smaller than the log did.



The Conservation of Mass

- In fact, the mass of the ashes is less than that of the log.

The Conservation of Mass

- However, suppose that you could collect all the oxygen in the air that was combined with the log during the burning and all the smoke and gases that escaped from the burning log and measure their masses, too.
- Then you would find that no mass was lost after all.

The Conservation of Mass

- Not only is no mass lost during burning, mass is not gained or lost during any chemical change.
- According to the **law of conservation of mass**, the mass of all substances that are present before a chemical change equals the mass of all the substances that remain after the change.

Lecture Plus SRS: Session 3

Ch. 17 Properties of Atoms and the Periodic Table
McLaughlin, C.W., Thompson, M. T., & Zike, D.(2010). *Tennessee Physical Science. McGraw-Hill, Inc.*

Scientific Shorthand

- For some elements, the symbol is the first letter of the element's name.
- For other elements, the symbol is the first letter of the name plus another letter from its name.
- Because scientists worldwide use this system, everyone understands what the symbols mean.

Scientific Shorthand

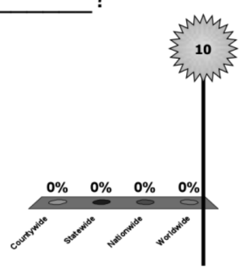
- Scientists have developed their own shorthand for dealing with long, complicated names.
- Chemical symbols consist of one capital letter or a capital letter plus one or two smaller letters.
- The periodic table is made up of elements.

Symbols of Some Elements

Element	Symbol	Element	Symbol
Aluminum	Al	Iron	Fe
Calcium	Ca	Mercury	Hg
Carbon	C	Nitrogen	N
Chlorine	Cl	Oxygen	O
Gold	Au	Potassium	K
Hydrogen	H	Sodium	Na

Question 1: Scientific shorthand is used __________?

1. Countywide
2. Statewide
3. Nationwide
4. Worldwide



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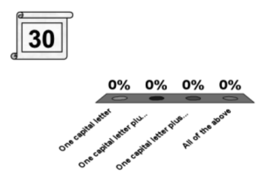
Question 2: Chemical symbols may consist of ______?

1. One capital letter
2. One capital letter plus one smaller letter
3. One capital letter plus two smaller letters
4. All of the above



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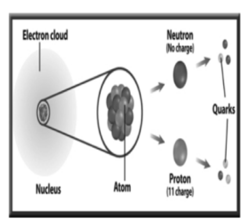
Atomic Components

- An element is matter that is composed of one type of **atom**, which is the smallest piece of matter that still retains the property of the element.
- Atoms are composed of particles called protons, neutrons, and electrons.

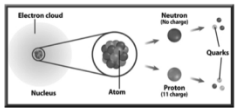
Atomic Components

- Protons and neutrons are found in a small positively charged center of the atom called the **nucleus** that is surrounded by a cloud containing electrons.
- **Protons** are particles with an electrical charge of 1+.



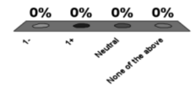
Atomic Components

- **Electrons** are particles with an electrical charge of 1–.
- **Neutrons** are neutral particles that do not have an electrical charge.



Question 3: Which of the following is the electrical charge of a proton?

1. 1-
2. 1+
3. Neutral
4. None of the above



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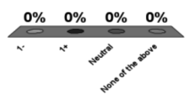
Question 4: Which of the following is the electrical charge of an electron?

1. 1-
2. 1+
3. Neutral
4. None of the above



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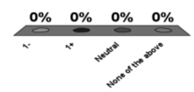
Question 5: Which of the following is the electrical charge of a neutron?

1. 1-
2. 1+
3. Neutral
4. None of the above



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Models—Tools for Scientists

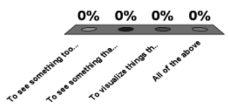
- Scientists and engineers use models to represent things that are difficult to visualize—or picture in your mind.
- Scaled-down models allow you to see either something too large to see all at once, or something that has not been built yet.
- Scaled-up models are often used to visualize things that are too small to see.

Models—Tools for Scientists

- To study the atom, scientists have developed scaled-up models that they can use to visualize how the atom is constructed.
- For the model to be useful, it must support all of the information that is known about matter and the behavior of atoms.

Question 6: Why do scientists use models?

1. To see something too large to see at once
2. To see something that has not yet been built
3. To visualize things that are too small to see
4. All of the above



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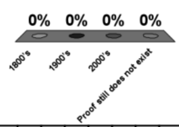
The Changing Atomic Model

- In the 1800s, John Dalton, an English scientist, was able to offer proof that atoms exist.
- Another famous Greek philosopher, Aristotle, disputed Democritus's theory and proposed that matter was uniform throughout and was not composed of smaller particles.

Question 7: When did John Dalton offer proof that atoms exist?

1. 1800's
2. 1900's
3. 2000's
4. Proof still does not exist



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- In the 1800s, John Dalton, an English scientist, was able to offer proof that atoms exist.
- Dalton's model of the atom, a solid sphere was an early model of the atom.
- The model has changed somewhat over time.
- The following are examples of atomic models: Rutherford, Bohr, Thomson.
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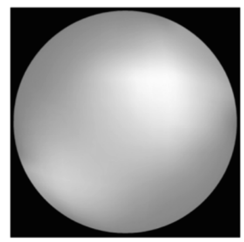
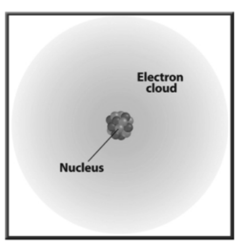


The Electron Cloud Model

- By 1926, scientists had developed the electron cloud model of the atom that is in use today.
- An **electron cloud** is the area around the nucleus of an atom where its electrons are most likely found.



The Electron Cloud Model

- The electron cloud is 100,000 times larger than the diameter of the nucleus.
- In contrast, each electron in the cloud is much smaller than a single proton.
- Because an electron's mass is small and the electron is moving so quickly around the nucleus, it is impossible to describe its exact location in an atom.

Question 9: The electronic cloud is ___________ times larger than the diameter of the nucleus.

1. 100
2. 1,000
3. 10,000
4. 100,000

The Electron Cloud Model

- There are 7 energy levels in the electron cloud.
- First energy level= 2 electrons
- Second energy level= 8 electrons
- Third energy level= 8 electrons
- Fourth energy level= 18 electrons

Question 8: How many energy levels are make up the electron cloud?

1. 3
2. 10
3. 7
4. 1

Question 9: How many electrons are found in the first energy level in the electron cloud?

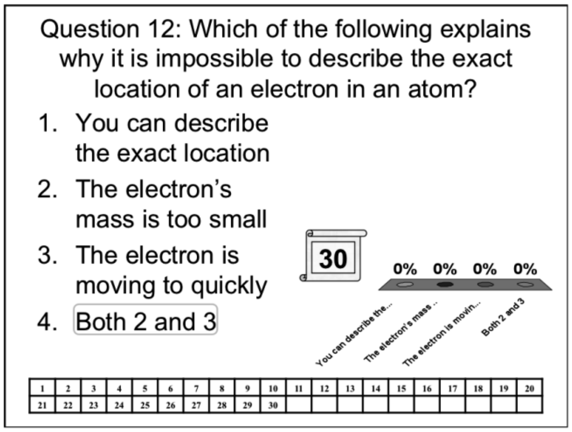
1. 2
2. 10
3. 8
4. 18

Question 10: How electrons are found in both the second energy level in the electron cloud?

1. 10
2. 2
3. 8
4. 18

Question 11: How many electrons are found in the fourth energy level of the electron cloud?

1. 18
2. 8
3. 2
4. 10


Question 12: Which of the following explains why it is impossible to describe the exact location of an electron in an atom?
1. You can describe the exact location
2. The electron's mass is too small
3. The electron is moving to quickly
4. Both 2 and 3
30
0% 0% 0% 0%
You can describe the...
The electron's mass ...
The electron is movin...
Both 2 and 3

Ch. 17 Properties of Atoms and the Periodic Table
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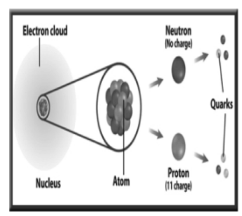

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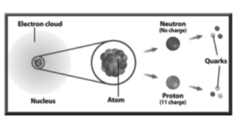

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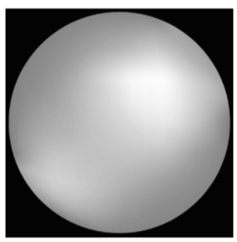

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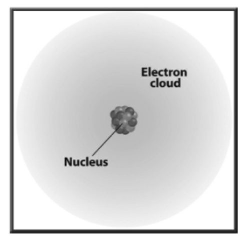

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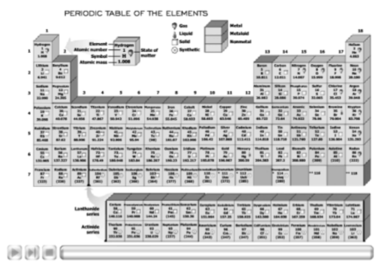
Lecture Plus SRS: Session 4

Masses of Atoms

McLaughlin, C.W., Thompson, M. T., & Zike, D.(2010). *Tennessee Physical Science. McGraw-Hill, Inc.*

Atomic Mass



Atomic Mass

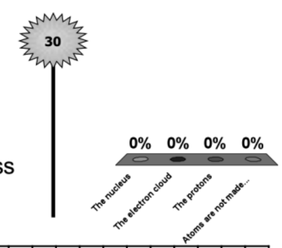
- The nucleus contains most of the mass of the atom because protons and neutrons are far more massive than electrons.
- The mass of a proton is about the same as that of a neutron—approximately

Subatomic Particle Masses

Particle	Mass (g)
Proton	1.6726×10^{-24}
Neutron	1.6749×10^{-24}
Electron	9.1093×10^{-28}

Question 1: Where is the majority of the mass located in an atom?

1. The nucleus
2. The electron cloud
3. The protons
4. Atoms are not made up of mass



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21	22	23	24	25	26	27	28	29	30										

Atomic Mass

- The mass of each is approximately 1,836 times greater than the mass of the electron.

Subatomic Particle Masses

Particle	Mass (g)
Proton	1.6726×10^{-24}
Neutron	1.6749×10^{-24}
Electron	9.1093×10^{-28}

Atomic Mass

- The unit of measurement used for atomic particles is the atomic mass unit (amu).
- The mass of a proton or a neutron is almost equal to 1 amu.
- The atomic mass unit is defined as one-twelfth the mass of a carbon atom containing six protons and six neutrons.

Protons Identify the Element

- The number of protons tells you what type of atom you have and vice versa. For example, every carbon atom has six protons. Also, all atoms with six protons are carbon atoms.
- The number of protons in an atom is equal to a number called the **atomic number**.

Mass Number

- The **mass number** of an atom is the sum of the number of protons and the number of neutrons in the nucleus of an atom.

Mass Numbers of Some Atoms

Element	Symbol	Atomic Number	Protons	Neutrons	Mass Number	Average Atomic Mass*
Boron	B	5	5	6	11	10.81 amu
Carbon	C	6	6	6	12	12.01 amu
Oxygen	O	8	8	8	16	16.00 amu
Sodium	Na	11	11	12	23	22.99 amu
Copper	Cu	29	29	34	63	63.55 amu

*The atomic mass units are rounded to two decimal places.

Mass Number

- If you know the mass number and the atomic number of an atom, you can calculate the number of neutrons.

number of neutrons = mass number – atomic number

Mass Numbers of Some Atoms

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Oxygen	O	8	8	8	16	16.00 amu
Sodium	Na	11	11	12	23	22.99 amu
Copper	Cu	29	29	34	63	63.55 amu

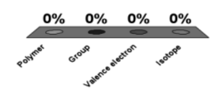
*The atomic mass units are rounded to two decimal places.

Isotopes

- Not all the atoms of an element have the same number of neutrons.
- Atoms of the same element that have different numbers of neutrons are called **isotopes**

Question 2: What is the name of the same atom with a different number of neutrons is called?

1. Polymer
2. Group
3. Valence electron
4. Isotope



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Identifying Isotopes

- Models of two isotopes of boron are shown. Because the numbers of neutrons in the isotopes are different, the mass numbers are also different.
- You use the name of the element followed by the mass number of the isotope to identify each isotope: boron-10 and boron-11.

Identifying Isotopes

- The **average atomic mass** of an element is the weighted-average mass of the mixture of its isotopes.
- For example, four out of five atoms of boron are boron-11, and one out of five is boron-10.
- To find the weighted-average or the average atomic mass of boron, you would solve the following equation:

$$\frac{4}{5}(11 \text{ amu}) + \frac{1}{5}(10 \text{ amu}) = 10.8 \text{ amu}$$

Organizing the Elements

- *Periodic* means "repeated in a pattern."
- In the late 1800s, Dmitri Mendeleev, a Russian chemist, searched for a way to organize the elements.
- When he arranged all the elements known at that time in order of increasing atomic masses, he discovered a pattern.

Organizing the Elements

- Because the pattern repeated, it was considered to be periodic. Today, this arrangement is called a periodic table of elements.
- In the **periodic table**, the elements are arranged by increasing atomic number and by changes in physical and chemical properties.

Mendeleev's Predictions

- Mendeleev had to leave blank spaces in his periodic table to keep the elements properly lined up according to their chemical properties.
- He looked at the properties and atomic masses of the elements surrounding these blank spaces.

Mendeleev's Predictions

- From this information, he was able to predict the properties and the mass numbers of new elements that had not yet been discovered.

Mendeleev's Predictions

Predicted Properties of Ekasilicon (Es)	Actual Properties of Germanium (Ge)
Existence Predicted—1871	*Actual Discovery*—1886
Atomic mass = 72	Atomic mass = 72.61
High melting point	Melting point = 9388C
Density = 5.5 g/cm^3	Density = 5.323 g/cm^3
Dark gray metal	Gray metal
Density of EsO_2 = 4.7 g/cm^3	Density of GeO_2 = 4.23 g/cm^3

Mendeleev's Predictions

- This table shows Mendeleev's predicted properties for germanium, which he called ekasilicon. His predictions proved to be accurate.

Mendeleev's Predictions

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Improving the Periodic Table

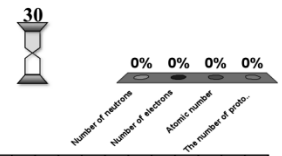
- On Mendeleev's table, the atomic mass gradually increased from left to right. If you look at the modern periodic table, you will see several examples, such as cobalt and nickel, where the mass decreases from left to right.

Improving the Periodic Table

- In 1913, the work of Henry G.J. Moseley, a young English scientist, led to the arrangement of elements based on their increasing atomic numbers instead of an arrangement based on atomic masses.
- The current periodic table uses Moseley's arrangement of the elements.

Question 3: How are the elements arranged on the Periodic Table?

1. Number of neutrons
2. Number of electrons
3. Atomic number
4. The number of protons plus neutrons



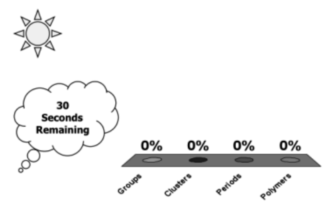
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
21	22	23	24	25	26	27	28	29	30										

The Atom and the Periodic Table

- The vertical columns in the periodic table are called **groups**, or families, and are numbered 1 through 18.
- Elements in each group have similar properties.

Question 4: What are the vertical columns in the Periodic Table called?

1. Groups
2. Clusters
3. Periods
4. Polymers



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Electron Cloud Structure

- In a neutral atom, the number of electrons is equal to the number of protons.
- Therefore, a carbon atom, with an atomic number of six, has six protons and six electrons.

Electron Cloud Structure

- Scientists have found that electrons within the electron cloud have different amounts of energy.
- Scientists model the energy differences of the electrons by placing the electrons in energy levels.

Electron Cloud Structure

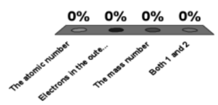
- Energy levels nearer the nucleus have lower energy than those levels that are farther away.
- Electrons fill these energy levels from the inner levels (closer to the nucleus) to the outer levels (farther from the nucleus).

Electron Cloud Structure

- Elements that are in the same group have the same number of electrons in their outer energy level.
- It is the number of electrons in the outer energy level that determines the chemical properties of the element.

Question 5: What determines the chemical property of an element?

1. The atomic number
2. Electrons in the outer energy level
3. The mass number
4. Both 1 and 2



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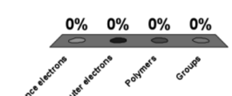
Energy Levels

- An energy level one can contain a maximum of two electrons.
- A complete and stable outer energy level will contain eight electrons.
- Electrons in the outer energy level are referred to valence electrons.
- Group 1 has 1 valence electron
- Group 2 has 2 valence electrons
- Groups 3-12 have 2 valence electrons with the exception it has 1
- Group 13 has 3 valence electrons
- Group 14 has 4 etc.

Question 6: What are the electrons in the outer most energy level called?

1. Valence electrons
2. Outer electrons
3. Polymers
4. Groups



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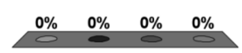
Question 7: How many electrons make a complete and stable outer energy level?

1. 6
2. 18
3. 10
4. 8



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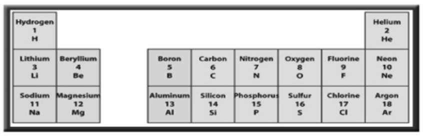
21	22	23	24	25	26	27	28	29	30										

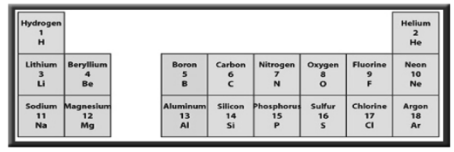
Rows on the Table

- Remember that the atomic number found on the periodic table is equal to the number of electrons in an atom.
- Remember in a neutral atom, atomic number equals the number of protons and electrons (positive and negatives= neutral)
- Show the atomic number



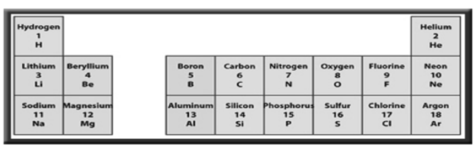
Rows on the Table

- The first row has hydrogen with one electron and helium with two electrons both in energy level one.
- Energy level one can hold only two electrons. Therefore, helium has a full or complete outer energy level.



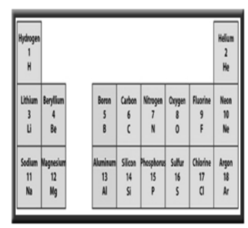
Rows on the Table

- The second row begins with lithium, which has three electrons—two in energy level one and one in energy level two.
- Lithium is followed by beryllium with two outer electrons, boron with three, and so on until you reach neon with eight outer electrons.



Rows on the Table

- Do you notice how the row in the periodic table ends when an outer level is filled?
- In the third row of elements, the electrons begin filling energy level three.
- The row ends with argon, which has a full outer energy level of eight electrons.

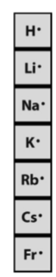


Electron Dot Diagrams

- Elements that are in the same group have the same number of electrons in their outer energy level.
- These outer electrons are so important in determining the chemical properties of an element that a special way to represent them has been developed.

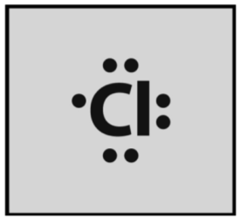
Electron Dot Diagrams

- An **electron dot diagram** uses the symbol of the element and dots to represent the electrons in the outer energy level.
- Electron dot diagrams are used also to show how the electrons in the outer energy level are bonded when elements combine to form compounds.



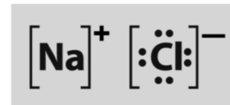
Same Group—Similar Properties

- The elements in Group 17, the halogens, have electron dot diagrams similar to chlorine.
- All halogens have seven electrons in their outer energy levels.



Same Group—Similar Properties

- A common property of the halogens is the ability to form compounds readily with elements in Group 1.
- The Group 1 element, sodium, reacts easily with the Group 17 element, chlorine.
- The result is the compound sodium chloride, or NaCl—ordinary table salt.

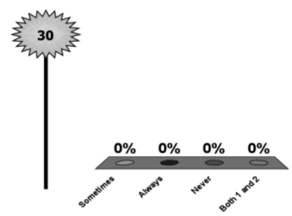


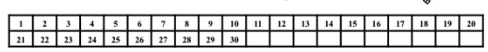
Same Group—Similar Properties

- Not all elements will combine readily with other elements.
- The elements in Group 18 have complete outer energy levels.
- This special configuration makes Group 18 elements relatively unreactive.

Question 8: When can elements in group 18 on the Periodic Table combine with other elements?

1. Sometimes
2. Always
3. Never
4. Both 1 and 2



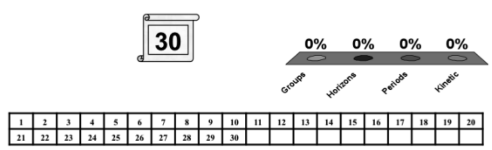


Regions on the Periodic Table

- The periodic table has several regions with specific names.
- The horizontal rows of elements on the periodic table are called **periods**.
- The elements increase by one proton and one electron as you go from left to right in a period.

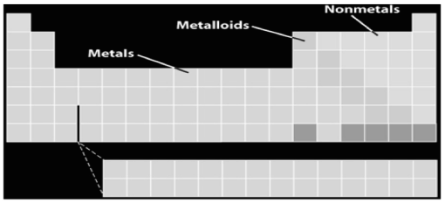
Question 9: The horizontal rows on the Periodic Table are called ________.

1. Groups
2. Horizons
3. Periods
4. Kinetic



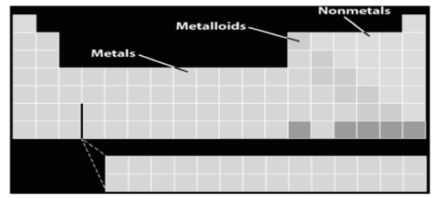
Regions on the Periodic Table

- All of the elements in the blue squares are metals.



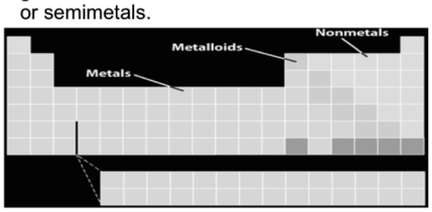
Regions on the Periodic Table

- Those elements on the right side of the periodic table, in yellow, are classified as nonmetals.



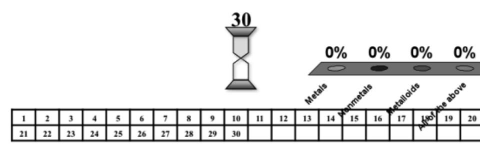
Regions on the Periodic Table

- The elements in green are metalloids or semimetals.



Question 10: Which of the following are regions on the Periodic Table?

1. Metals
2. Nonmetals
3. Metalloids
4. All of the above



A Growing Family

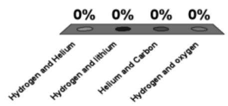
- In 1994, scientists at the Heavy-Ion Research Laboratory in Darmstadt, Germany, discovered element 111.
- Element 112 was discovered at the same laboratory.
- Both of these elements are produced in the laboratory by joining smaller atoms into a single atom.

Elements in the Universe

- Using the technology that is available today, scientists are finding the same elements throughout the universe.
- Many scientists believe that hydrogen and helium are the building blocks of other elements.

Question 11: Which elements are believed to be by many scientists the building blocks of other elements?

1. Hydrogen and Helium
2. Hydrogen and lithium
3. Helium and Carbon
4. Hydrogen and oxygen



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21	22	23	24	25	26	27	28	29	30										

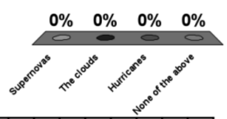
Elements in the Universe

- Exploding stars, or supernovas, give scientists evidence to support this theory.
- Many scientists believe that supernovas have spread the elements that are found throughout the universe.

Question 12: Scientists believe that ________ have spread the elements throughout the universe.

1. Supernovas
2. The clouds
3. Hurricanes
4. None of the above

30



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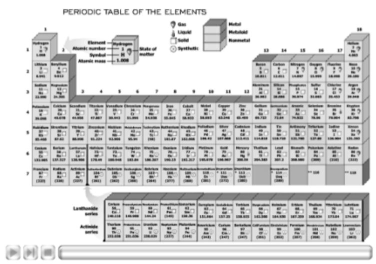
Lecture: Session 4

Masses of Atoms
McLaughlin, C.W., Thompson, M. T., & Zike, D.(2010). *Tennessee Physical Science. McGraw-Hill, Inc.*

Atomic Mass



Atomic Mass

- The nucleus contains most of the mass of the atom because protons and neutrons are far more massive than electrons.
- The mass of a proton is about the same as that of a neutron—approximately

Subatomic Particle Masses

Particle	Mass (g)
Proton	1.6726×10^{-24}
Neutron	1.6749×10^{-24}
Electron	9.1093×10^{-28}

Atomic Mass

- The mass of each is approximately 1,836 times greater than the mass of the electron.

Subatomic Particle Masses

Particle	Mass (g)
Proton	1.6726×10^{-24}
Neutron	1.6749×10^{-24}
Electron	9.1093×10^{-28}

Atomic Mass

- The unit of measurement used for atomic particles is the atomic mass unit (amu).
- The mass of a proton or a neutron is almost equal to 1 amu.
- The atomic mass unit is defined as one-twelfth the mass of a carbon atom containing six protons and six neutrons.

Protons Identify the Element

- The number of protons tells you what type of atom you have and vice versa. For example, every carbon atom has six protons. Also, all atoms with six protons are carbon atoms.
- The number of protons in an atom is equal to a number called the **atomic number**.

Mass Number

- The **mass number** of an atom is the sum of the number of protons and the number of neutrons in the nucleus of an atom.

Mass Numbers of Some Atoms

Element	Symbol	Atomic Number	Protons	Neutrons	Mass Number	Average Atomic Mass*
Boron	B	5	5	6	11	10.81 amu
Carbon	C	6	6	6	12	12.01 amu
Oxygen	O	8	8	8	16	16.00 amu
Sodium	Na	11	11	12	23	22.99 amu
Copper	Cu	29	29	34	63	63.55 amu

*The atomic mass units are rounded to two decimal places.

Mass Number

- If you know the mass number and the atomic number of an atom, you can calculate the number of neutrons.

number of neutrons = mass number – atomic number

Mass Numbers of Some Atoms

Element	Symbol	Atomic Number	Protons	Neutrons	Mass Number	Average Atomic Mass*
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Sodium	Na	11	11	12	23	22.99 amu
Copper	Cu	29	29	34	63	63.55 amu

*The atomic mass units are rounded to two decimal places.

Isotopes

- Not all the atoms of an element have the same number of neutrons.
- Atoms of the same element that have different numbers of neutrons are called **isotopes**

Identifying Isotopes

- Models of two isotopes of boron are shown. Because the numbers of neutrons in the isotopes are different, the mass numbers are also different.
- You use the name of the element followed by the mass number of the isotope to identify each isotope: boron-10 and boron-11.

Identifying Isotopes

- The **average atomic mass** of an element is the weighted-average mass of the mixture of its isotopes.
- For example, four out of five atoms of boron are boron-11, and one out of five is boron-10.
- To find the weighted-average or the average atomic mass of boron, you would solve the following equation:

$$\frac{4}{5}(11\text{ amu}) + \frac{1}{5}(10\text{ amu}) = 10.8\text{ amu}$$

Organizing the Elements

- *Periodic* means "repeated in a pattern."
- In the late 1800s, Dmitri Mendeleev, a Russian chemist, searched for a way to organize the elements.
- When he arranged all the elements known at that time in order of increasing atomic masses, he discovered a pattern.

Organizing the Elements

- Because the pattern repeated, it was considered to be periodic. Today, this arrangement is called a periodic table of elements.
- In the **periodic table**, the elements are arranged by increasing atomic number and by changes in physical and chemical properties.

Mendeleev's Predictions

- Mendeleev had to leave blank spaces in his periodic table to keep the elements properly lined up according to their chemical properties.
- He looked at the properties and atomic masses of the elements surrounding these blank spaces.

Mendeleev's Predictions

- From this information, he was able to predict the properties and the mass numbers of new elements that had not yet been discovered.

Mendeleev's Predictions

Predicted Properties of Ekasilicon (Es)	Actual Properties of Germanium (Ge)
Existence Predicted—1871	*Actual Discovery*—1886
Atomic mass = 72	Atomic mass = 72.61
High melting point	Melting point = 9388C
Density = 5.5 g/cm^3	Density = 5.323 g/cm^3
Dark gray metal	Gray metal
Density of EsO_2 = 4.7 g/cm^3	Density of GeO_2 = 4.23 g/cm^3

Mendeleev's Predictions

- This table shows Mendeleev's predicted properties for germanium, which he called ekasilicon. His predictions proved to be accurate.

Mendeleev's Predictions

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Improving the Periodic Table

- On Mendeleev's table, the atomic mass gradually increased from left to right. If you look at the modern periodic table, you will see several examples, such as cobalt and nickel, where the mass decreases from left to right.

Improving the Periodic Table

- In 1913, the work of Henry G.J. Moseley, a young English scientist, led to the arrangement of elements based on their increasing atomic numbers instead of an arrangement based on atomic masses.
- The current periodic table uses Moseley's arrangement of the elements.

The Atom and the Periodic Table

- The vertical columns in the periodic table are called **groups**, or families, and are numbered 1 through 18.
- Elements in each group have similar properties.

Electron Cloud Structure

- In a neutral atom, the number of electrons is equal to the number of protons.
- Therefore, a carbon atom, with an atomic number of six, has six protons and six electrons.

Electron Cloud Structure

- Scientists have found that electrons within the electron cloud have different amounts of energy.
- Scientists model the energy differences of the electrons by placing the electrons in energy levels.

Electron Cloud Structure

- Energy levels nearer the nucleus have lower energy than those levels that are farther away.
- Electrons fill these energy levels from the inner levels (closer to the nucleus) to the outer levels (farther from the nucleus).

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Energy Levels

- An energy level one can contain a maximum of two electrons.
- A complete and stable outer energy level will contain eight electrons.
- Electrons in the outer energy level are referred to valence electrons.
- Group 1 has 1 valence electron
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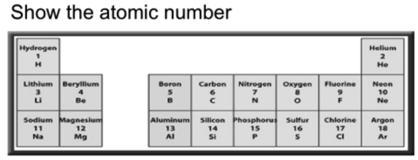
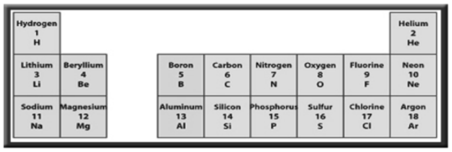
Rows on the Table

- Remember that the atomic number found on the periodic table is equal to the number of electrons in an atom.
- Remember in a neutral atom, atomic number equals the number of protons and electrons (positive and negatives= neutral)
- Show the atomic number



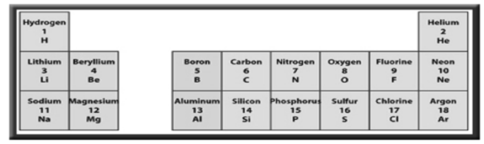
Rows on the Table

- The first row has hydrogen with one electron and helium with two electrons both in energy level one.
- Energy level one can hold only two electrons. Therefore, helium has a full or complete outer energy level.



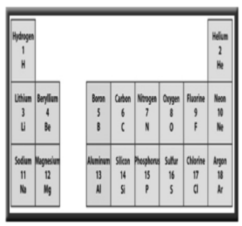
Rows on the Table

- The second row begins with lithium, which has three electrons—two in energy level one and one in energy level two.
- Lithium is followed by beryllium with two outer electrons, boron with three, and so on until you reach neon with eight outer electrons.



Rows on the Table

- Do you notice how the row in the periodic table ends when an outer level is filled?
- In the third row of elements, the electrons begin filling energy level three.
- The row ends with argon, which has a full outer energy level of eight electrons.



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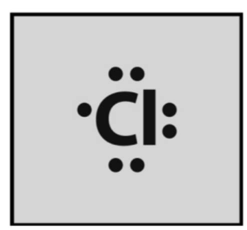
Electron Dot Diagrams

- An **electron dot diagram** uses the symbol of the element and dots to represent the electrons in the outer energy level.
- Electron dot diagrams are used also to show how the electrons in the outer energy level are bonded when elements combine to form compounds.

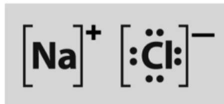
Same Group—Similar Properties

- The elements in Group 17, the halogens, have electron dot diagrams similar to chlorine.
- All halogens have seven electrons in their outer energy levels.



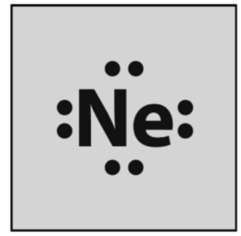
Same Group—Similar Properties

- A common property of the halogens is the ability to form compounds readily with elements in Group 1.
- The Group 1 element, sodium, reacts easily with the Group 17 element, chlorine.
- The result is the compound sodium chloride, or NaCl—ordinary table salt.



Same Group—Similar Properties

- Not all elements will combine readily with other elements.
- The elements in Group 18 have complete outer energy levels.
- This special configuration makes Group 18 elements relatively unreactive.

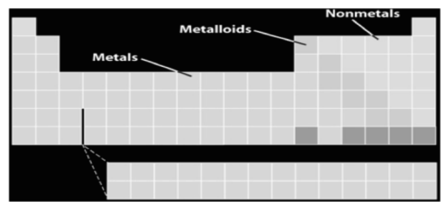


Regions on the Periodic Table

- The periodic table has several regions with specific names.
- The horizontal rows of elements on the periodic table are called **periods**.
- The elements increase by one proton and one electron as you go from left to right in a period.

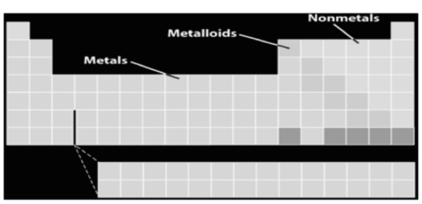
Regions on the Periodic Table

- All of the elements in the blue squares are metals.



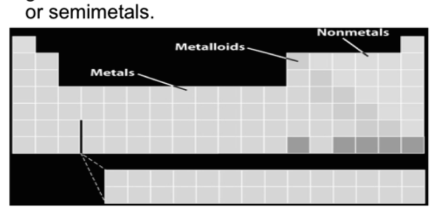
Regions on the Periodic Table

- Those elements on the right side of the periodic table, in yellow, are classified as nonmetals.



Regions on the Periodic Table

- The elements in green are metalloids or semimetals.



A Growing Family

- In 1994, scientists at the Heavy-Ion Research Laboratory in Darmstadt, Germany, discovered element 111.
- Element 112 was discovered at the same laboratory.
- Both of these elements are produced in the laboratory by joining smaller atoms into a single atom.

Elements in the Universe

- Using the technology that is available today, scientists are finding the same elements throughout the universe.
- Many scientists believe that hydrogen and helium are the building blocks of other elements.

Elements in the Universe

- Exploding stars, or supernovas, give scientists evidence to support this theory.
- Many scientists believe that supernovas have spread the elements that are found throughout the universe.

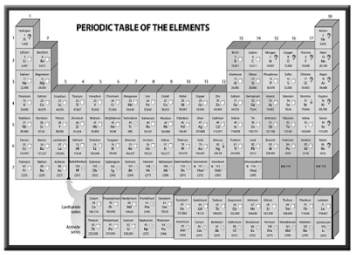
Lecture Plus SRS: Session 5

Ch. 19: Elements and Their Properties

McLaughlin, C.W., Thompson, M. T., & Zike, D.(2010). *Tennessee Physical Science. McGraw-Hill, Inc.*

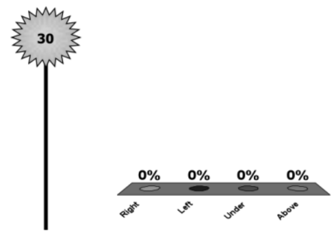
Metals
Properties of Metals

- In the periodic table, metals are elements found to the left of the stair-step line.



Question 1: Metals are found to the ____ of the stair step line on the periodic table.

1. Right
2. Left
3. Under
4. Above



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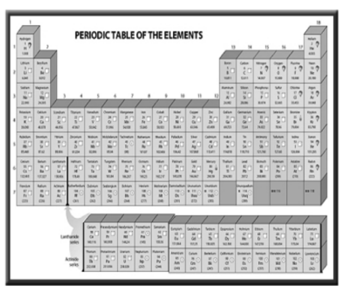
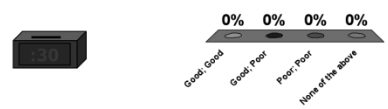
Metals
Properties of Metals

- **Metals** usually have common properties—they are good conductors of heat and electricity, and all but one are solid at room temperature.



Question 2: Metals are ____ conductors of heat and ____ conductors of electricity.

1. Good; Good
2. Good; Poor
3. Poor; Poor
4. None of the above



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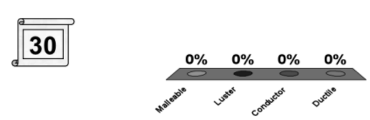
Metals
Properties of Metals

- Metals also reflect light. This is a property called luster.
- Metals are **malleable** (MAL yuh bul), which means they can be hammered or rolled into sheets.
- Metals are also **ductile**, which means they can be drawn into wires.

Question 3: Metals can be drawn into wires. This property is called ___.

1. Malleable
2. Luster
3. Conductor
4. Ductile



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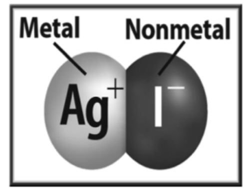
Metals
Ionic Bonding in Metals

- The atoms of metals generally have one to three electrons in their outer energy levels.
- In chemical reactions, metals tend to give up electrons easily because of the strength of charge of the protons in the nucleus.

Metals
Ionic Bonding in Metals

- When metals combine with nonmetals, the atoms of the metals tend to lose electrons to the atoms of nonmetals, forming ionic bonds.
- Both metals and nonmetals become more chemically stable when they form ions.



Question 4: Both metals and nonmetals become _____ chemically stable when they form ions.

1. Less
2. Neutral
3. More
4. No change occurs

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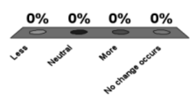

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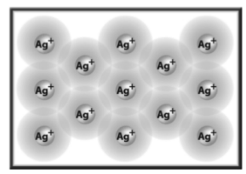
Metals
Metallic Bonding

- In **metallic bonding**, positively charged metallic ions are surrounded by a cloud of electrons.
- Outer-level electrons are not held tightly to the nucleus of an atom. Rather, the electrons move freely among many positively charged ions.

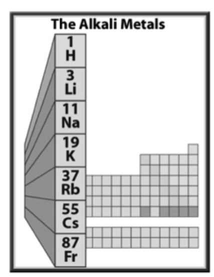


Metals
Metallic Bonding

- The idea of metallic bonding explains many of the properties of metals.
- When a metal is hammered into a sheet or drawn into a wire, it does not break because the ions are in layers that slide past one another without losing their attraction to the electron cloud.
- Metals are also good conductors of electricity because the outer-level electrons are weakly held.

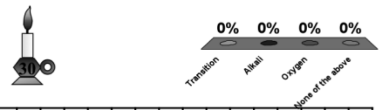
Metals
The Alkali Metals

- The elements in Group 1 of the periodic table are the alkali (AL kuh li) metals.
- Group 1 metals are shiny, malleable, and ductile.
- They are also good conductors of heat and electricity. However, they are softer than most other metals.



Question 5: Group 1 on the periodic table are the _____ metals.

1. Transition
2. Alkali
3. Oxygen
4. None of the above



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Metals
The Alkali Metals

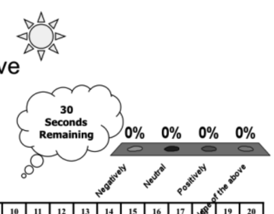
- The alkali metals are the most reactive of all the metals. They react rapidly—sometimes violently—with oxygen and water.
- Alkali metals don't occur in nature in their elemental form and are stored in substances that are unreactive, such as an oil.

Metals
The Alkali Metals

- Each atom of an alkali metal has one electron in its outer energy level.
- This electron is given up when an alkali metal combines with another atom.
- As a result, the alkali metal becomes a positively charged ion in a compound such as sodium chloride.

Question 6: The electron in the outer energy level of an alkali metal is given up when it combines with another atom. As a result it becomes a ___ charged ion.

1. Negatively
2. Neutral
3. Positively
4. None of the above



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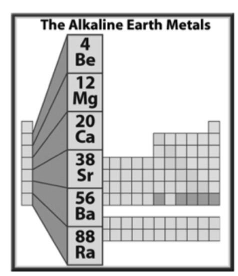
Metals
The Alkali Metals

- Alkali metals and their compounds have many uses.
- Doctors use lithium compounds to treat bipolar depression.
- The operation of some photocells depends upon rubidium or cesium compounds.
- Francium, the last element in Group 1, is extremely rare and radioactive.
- A **radioactive element** is one in which the nucleus breaks down and gives off particles and energy.

Metals
The Alkaline Earth Metals

- Each atom of an alkaline earth metal has two electrons in its outer energy level.



Metals
The Alkaline Earth Metals

- The alkaline earth metals make up Group 2 of the periodic table.
- These electrons are given up when an alkaline earth metal combines with a nonmetal.
- As a result, the alkaline earth metal becomes a positively charged ion in a compound such as calcium fluoride, CaF2.

Metals
Fireworks and Other Uses

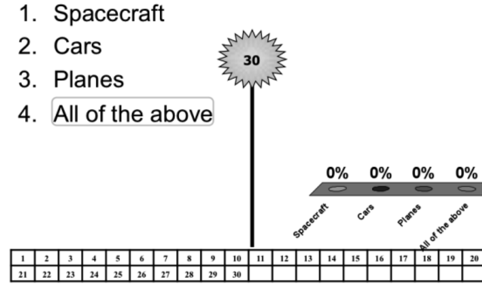
- Magnesium metal is one of the metals used to produce the brilliant white color in fireworks.
- Compounds of strontium produce the bright red flashes.

Metals
Fireworks and Other Uses

- Magnesium's lightness and strength account for its use in cars, planes, and spacecraft.
- Magnesium also is used in compounds to make such things as household ladders, and baseball and softball bats.

Question 7: Magnesium is used in which of the following?

1. Spacecraft
2. Cars
3. Planes
4. All of the above



Metals
The Alkaline Earth Metals and Your Body

- Calcium is seldom used as a free metal, but its compounds are needed for life.
- Calcium phosphate in your bones helps make them strong.

Metals
The Alkaline Earth Metals and Your Body

- The barium compound BaSO4 is used to diagnose some digestive disorders because it absorbs X-ray radiation well.
- Radium, the last element in Group 2, is radioactive and is found associated with uranium. It was once used to treat cancers.

Metals
Transition Elements

- **Transition elements** are those elements in Groups 3 through 12 in the periodic table.
- They are called transition elements because they are considered to be elements in transition between Groups 1 and 2 and Groups 13 through 18.

Question 8: Groups 3-12 on the periodic table are called _____.

1. Alkali elements
2. Metals
3. Ions elements
4. Transition elements

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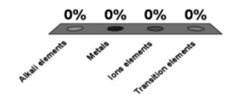

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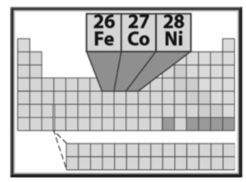
Metals
Transition Elements

- Transition elements are familiar because they often occur in nature as uncombined elements.
- Transition elements often form colored compounds.
- Gems show brightly colored compounds containing chromium.

Metals
Iron, Cobalt, and Nickel

- The first elements in Groups 8, 9, and 10—iron, cobalt, and nickel—form a unique cluster of transition elements.
- These three sometimes are called the iron triad.
- All three elements are used in the process to create steel and other metal mixtures.



Question 9: Which of the following is/are found in the iron triad?

1. Calcium
2. Iron
3. Nickel
4. Both 2 and 3

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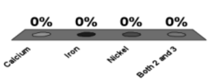

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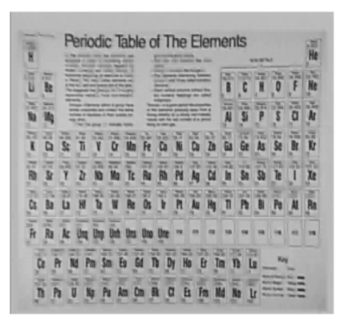
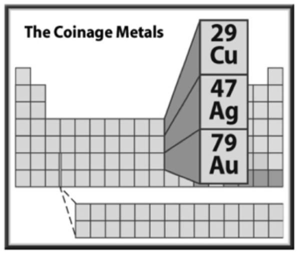
Metals
Iron, Cobalt, and Nickel

- Iron—the main component of steel—is the most widely used of all metals.
- Nickel is added to some metals to give them strength.



Metals
Copper, Silver, and Gold

- Copper, silver, and gold—the three elements in Group 11—are so stable that they can be found as free elements in nature.
- These metals were once used widely to make coins.
- For this reason, they are known as the coinage metals.

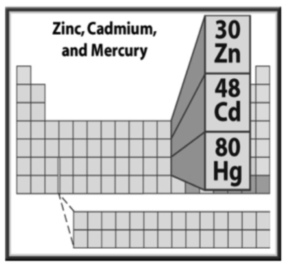


Metals
Copper, Silver, and Gold

- Copper often is used in electrical wiring because of its superior ability to conduct electricity and its relatively low cost.
- Silver iodide and silver bromide break down when exposed to light, producing an image on paper.
- Consequently, these compounds are used to make photographic film and paper.

Metals
Zinc, Cadmium, and Mercury

- Zinc, cadmium, and mercury are found in Group 12 of the periodic table.
- Zinc combines with oxygen in the air to form a thin, protective coating of zinc oxide on its surface.
- Zinc and cadmium often are used to coat, or plate, other metals such as iron because of this protective quality.

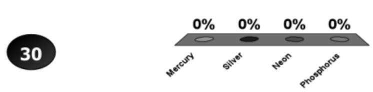


Metals
Zinc, Cadmium, and Mercury

- Mercury is a silvery, liquid metal—the only metal that is a liquid at room temperature.
- It is used in thermometers, thermostats, switches, and batteries.
- Mercury is poisonous and can accumulate in the body.

Question 10: _____ is the only metal that is a liquid at room temperature.

1. Mercury
2. Silver
3. Neon
4. Phosphorus



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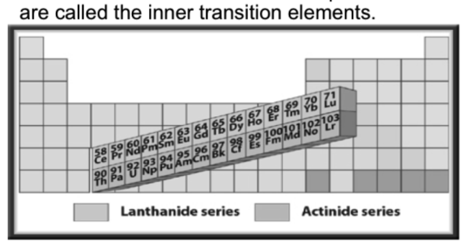
Metals
The Inner Transition Metals

- The two rows of elements that seem to be disconnected from the rest on the periodic table are called the inner transition elements.

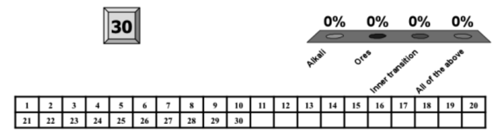


Metals
The Inner Transition Metals

- They are called this because like the transition elements, they fit in the periodic table between Groups 3 and 4 in periods 6 and 7, as shown.

Question 11: Which metals are found between groups 3 and 4 and periods 6 and 7?

1. Alkali
2. Ores
3. Inner transition
4. All of the above



Metals
The Lanthanides

- The first row includes a series of elements with atomic numbers of 58 to 71.
- These elements are called the lanthanide series because they follow the element lanthanum.

Metals
The Actinides

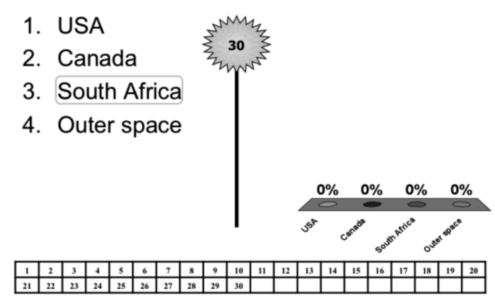
- The second row of inner transition metals includes elements with atomic numbers ranging from 90 to 103.
- These elements are called the actinide series because they follow the element actinium.
- All of the actinides are radioactive and unstable.
- Thorium and uranium are the actinides found in the Earth's crust in usable quantities.

Metals
Metals in the Crust

- Earth's hardened outer layer, called the crust, contains many compounds and a few uncombined metals such as gold and copper.
- Most of the world's platinum is found in South Africa.
- The United States imports most of its chromium from South Africa, the Philippines, and Turkey.

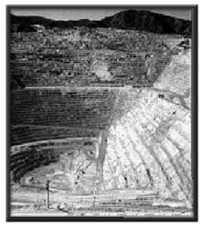
Question 12: Where is most of the world's platinum is found?

1. USA
2. Canada
3. South Africa
4. Outer space



Metals
Ores: Minerals and Mixtures

- Metals in Earth's crust that combined with other elements are found as ores.
- Most ores consist of a metal compound, or mineral, within a mixture of clay or rock.



Metals
Ores: Minerals and Mixtures

- After an ore is mined from Earth's crust, the rock is separated from the mineral.
- Then the mineral often is converted to another physical form.
- This step usually involves heat and is called roasting.

Lecture: Session 5

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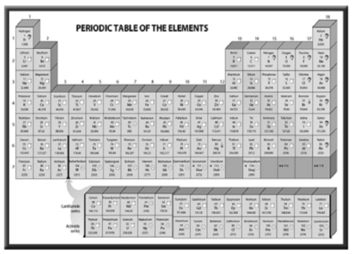

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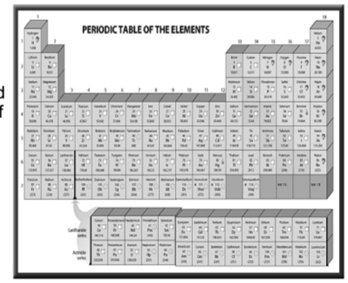

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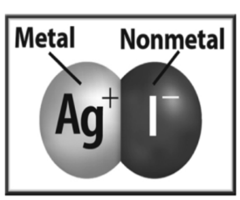

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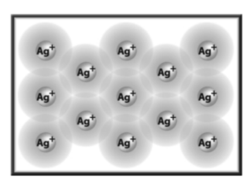

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The Alkali Metals

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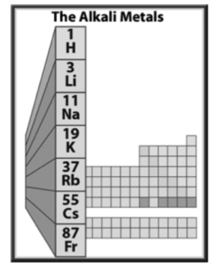

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Metals
The Alkali Metals

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Metals
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- Alkali metals and their compounds have many uses.
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Metals
The Alkaline Earth Metals

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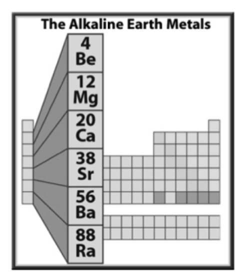

Metals
The Alkaline Earth Metals

- The alkaline earth metals make up Group 2 of the periodic table.
- These electrons are given up when an alkaline earth metal combines with a nonmetal.
- As a result, the alkaline earth metal becomes a positively charged ion in a compound such as calcium fluoride, CaF_2.

Metals
Fireworks and Other Uses

- Magnesium metal is one of the metals used to produce the brilliant white color in fireworks.
- Compounds of strontium produce the bright red flashes.

Metals
Fireworks and Other Uses

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Transition Elements

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- Gems show brightly colored compounds containing chromium.

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Iron, Cobalt, and Nickel

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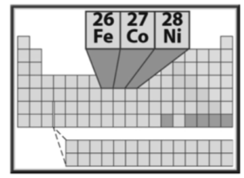

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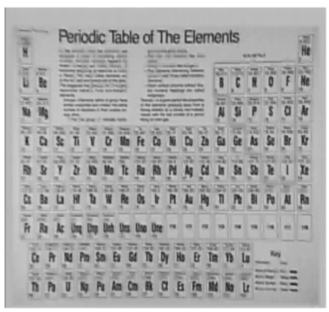
- Nickel is added to some metals to give them strength.



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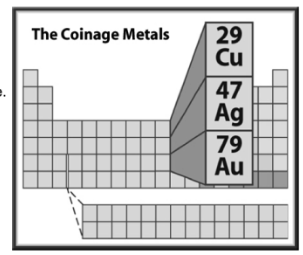
- These metals were once used widely to make coins.
- For this reason, they are known as the coinage metals.

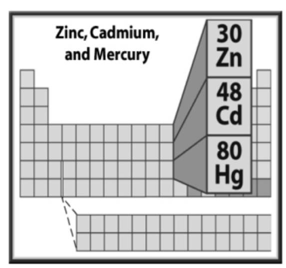


Metals
Copper, Silver, and Gold

- Copper often is used in electrical wiring because of its superior ability to conduct electricity and its relatively low cost.
- Silver iodide and silver bromide break down when exposed to light, producing an image on paper.
- Consequently, these compounds are used to make photographic film and paper.

Metals
Zinc, Cadmium, and Mercury

- Zinc, cadmium, and mercury are found in Group 12 of the periodic table.
- Zinc combines with oxygen in the air to form a thin, protective coating of zinc oxide on its surface.
- Zinc and cadmium often are used to coat, or plate, other metals such as iron because of this protective quality.

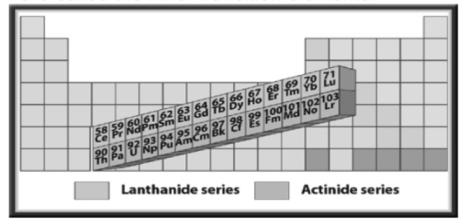


Metals
Zinc, Cadmium, and Mercury

- Mercury is a silvery, liquid metal—the only metal that is a liquid at room temperature.
- It is used in thermometers, thermostats, switches, and batteries.
- Mercury is poisonous and can accumulate in the body.

Metals
The Inner Transition Metals

- The two rows of elements that seem to be disconnected from the rest on the periodic table are called the inner transition elements.



Metals
The Inner Transition Metals

- They are called this because like the transition elements, they fit in the periodic table between Groups 3 and 4 in periods 6 and 7, as shown.

Metals
The Lanthanides

- The first row includes a series of elements with atomic numbers of 58 to 71.
- These elements are called the lanthanide series because they follow the element lanthanum.

Metals
The Actinides

- The second row of inner transition metals includes elements with atomic numbers ranging from 90 to 103.
- These elements are called the actinide series because they follow the element actinium.
- All of the actinides are radioactive and unstable.
- Thorium and uranium are the actinides found in the Earth's crust in usable quantities.

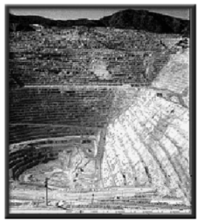
Metals
Metals in the Crust

- Earth's hardened outer layer, called the crust, contains many compounds and a few uncombined metals such as gold and copper.
- Most of the world's platinum is found in South Africa.
- The United States imports most of its chromium from South Africa, the Philippines, and Turkey.

Metals

Ores: Minerals and Mixtures

- Metals in Earth's crust that combined with other elements are found as ores.
- Most ores consist of a metal compound, or mineral, within a mixture of clay or rock.



Metals

Ores: Minerals and Mixtures

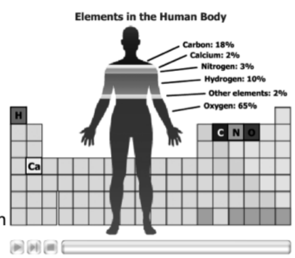
- After an ore is mined from Earth's crust, the rock is separated from the mineral.
- Then the mineral often is converted to another physical form.
- This step usually involves heat and is called roasting.

Lecture Plus SRS: Session 6

Elements and Their Properties
McLaughlin, C.W., Thompson, M. T., & Zike, D.(2010). *Tennessee Physical Science. McGraw-Hill, Inc.*

Nonmetals
Properties of Nonmetals

- Most of your body's mass is made of oxygen, carbon, hydrogen, and nitrogen.
- Calcium, a metal, and other elements make up the remaining four percent of your body's mass.
- Oxygen is the most abundant element in the body (65%)

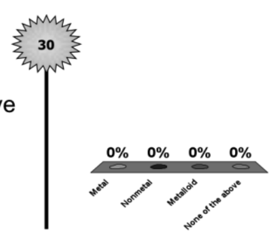


Nonmetals
Properties of Nonmetals

- Phosphorus, sulfur, and chlorine are among these other elements found in your body.
- These elements are classified as nonmetals.
- **Nonmetals** are elements that usually are gases or brittle solids at room temperature.

Question 1: ____ are elements that usually are gases or brittle solids at room temperature.

1. Metal
2. Nonmetal
3. Metalloid
4. None of the above



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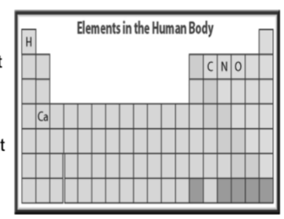
Nonmetals
Properties of Nonmetals

- Most nonmetals do not conduct heat or electricity well, and generally they are not shiny.
- In the periodic table, all nonmetals except hydrogen are found at the right of the stair-step line.



Nonmetals
Properties of Nonmetals

- The noble gases, Group 18, make up the only group of elements that are all nonmetals.
- Group 17 elements, except for astatine, are also nonmetals.

Nonmetals
Bonding in Nonmetals

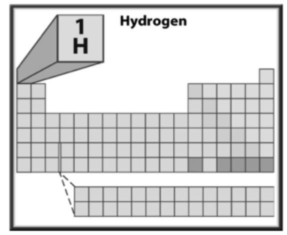
- The electrons in most nonmetals are strongly attracted to the nucleus of the atom. So, as a group, nonmetals are poor conductors of heat and electricity.
- Most nonmetals can form ionic and covalent compounds.

Nonmetals
Bonding in Nonmetals

- When nonmetals gain electrons from metals, the nonmetals become negative ions in ionic compounds.
- When bonded with other nonmetals, atoms of nonmetals usually share electrons to form covalent compounds.

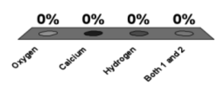
Nonmetals
Hydrogen

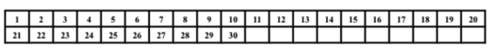
- If you could count all the atoms in the universe, you would find that about 90 percent of them are hydrogen.
- When water is broken down into its elements, hydrogen becomes a gas made up of diatomic molecules.



Question 2: Approximately 90% of all the atoms in the universe are ______?

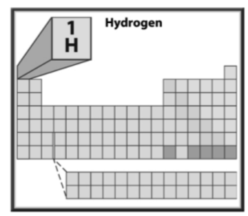
1. Oxygen
2. Calcium
3. Hydrogen
4. Both 1 and 2





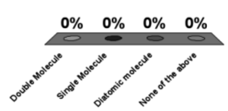
Nonmetals
Hydrogen

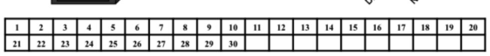
- A **diatomic molecule** consists of two atoms of the same element in a covalent bond.



Question 3: A ____ consists of two atoms of the same element in a covalent bond.

1. Double Molecule
2. Single Molecule
3. Diatomic molecule
4. None of the above



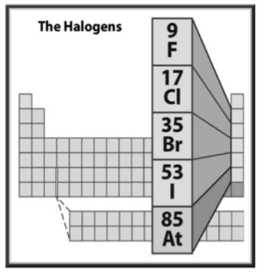


Nonmetals
Hydrogen

- Hydrogen is highly reactive.
- A hydrogen atom has a single electron, which the atom shares when it combines with other nonmetals.
- Hydrogen can gain an electron when it combines with alkali and alkaline earth metals.
- The compounds formed are hydrides.

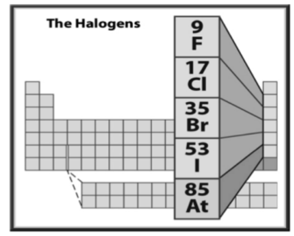
Nonmetals
The Halogens

- Halogen lights contain small amounts of bromine or iodine.
- These elements, as well as fluorine, chlorine, and astatine, are called halogens and are in Group 17.



Nonmetals
The Halogens

- They are very reactive in their elemental form, and their compounds have many uses.

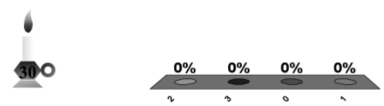


Nonmetals
The Halogens

- Because an atom of a halogen has seven electrons in its outer energy level, only one electron is needed to complete this energy level.
- If a halogen gains an electron from a metal, an ionic compound, called a **salt** is formed.

Question 4: An atom of a halogen has seven electrons in its outer energy level. How many electrons are needed to complete the outer energy level.

1. 2
2. 3
3. 0
4. 1



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Nonmetals
The Halogens

- In the gaseous state, the halogens form reactive diatomic covalent molecules and can be identified by their distinctive colors.
- Chlorine is greenish yellow, bromine is reddish orange, and iodine is violet.

Nonmetals
The Halogens

- Fluorine is the most chemically active of all elements.
- Hydrofluoric acid, a mixture of hydrogen fluoride and water, is used to etch glass and to frost the inner surfaces of lightbulbs and is also used in the fabrication of semiconductors.

Nonmetals
Uses of Halogens

- Chlorine compounds are used to disinfect water.
- Chlorine, the most abundant halogen, is obtained from seawater at ocean-salt recovery sites.
- Household and industrial bleaches used to whiten flour, clothing, and paper also contain chlorine compounds.

Nonmetals
Uses of Halogens

- Bromine, the only nonmetal that is a liquid at room temperature, also is extracted from compounds in seawater.
- Bromine compounds are used as dyes in cosmetics.

Nonmetals
Uses of Halogens

- Iodine, a shiny purple-gray solid at room temperature, is obtained from seawater.
- When heated, iodine changes directly to a purple vapor.
- The process of a solid changing directly to a vapor without forming a liquid is called **sublimation**.

Question 5: _____ the process of a solid changing directly into a vapor without forming a liquid.

1. Sublimation
2. Melting
3. Boiling
4. 1 and 2

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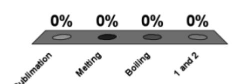

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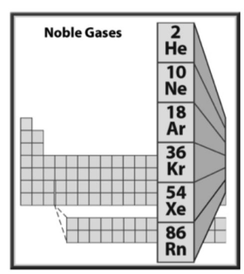
Nonmetals
Uses of Halogens

- Astatine is the last member of Group 17. It is radioactive and rare, but has many properties similar to those of the other halogens.
- There are no known uses due to its rarity.

Nonmetals
The Noble Gases

- The noble gases exist as isolated atoms.
- They are stable because their outermost energy levels are full.
- No naturally occurring noble gas compounds are known.



Nonmetals
The Noble Gases

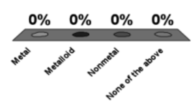
- The stability of noble gases is what makes them useful.
- The light weight of helium makes it useful in lighter-than-air blimps and balloons.
- Neon and argon are used in “neon lights” for advertising.

Mixed Groups
Properties of Metalloids

- Metalloids share unusual characteristics.
- **Metalloids** can form ionic and covalent bonds with other elements and can have metallic and nonmetallic properties.
- Some metalloids can conduct electricity better than most nonmetals, but not as well as some metals, giving them the name semiconductor.
- With the exception of aluminum, the metalloids are the elements in the periodic table that are located along the stair-step line.

Question 6: ____ can form ionic and covalent bonds with other elements and can have metallic and nonmetallic properties.

1. Metal
2. Metalloid
3. Nonmetal
4. None of the above



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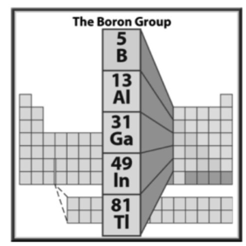
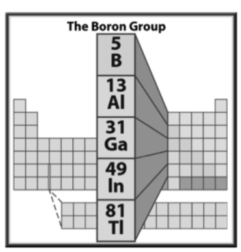
Mixed Groups
The Boron Group

- Boron, a metalloid, is the first element in Group 13.
- If you look around your home, you might find two compounds of boron.



Mixed Groups
The Boron Group

- One of these is borax, which is used in some laundry products to soften water.
- The other is boric acid, a mild antiseptic.

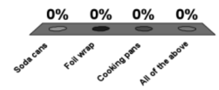


Mixed Groups
The Boron Group

- Aluminum, a metal in Group 13, is the most abundant metal in Earth’s crust.
- It is used in soft-drink cans, foil wrap, cooking pans, and as siding.
- Aluminum is strong and light and is used in the construction of airplanes.

Question 7: Aluminum is used in which of the following?

1. Soda cans
2. Foil wrap
3. Cooking pans
4. All of the above



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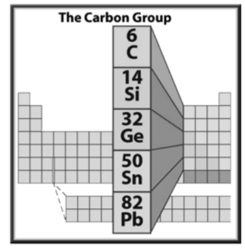
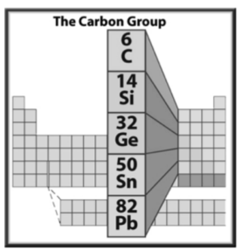
Mixed Groups
The Carbon Group

- Each element in Group 14, the carbon family, has four electrons in its outer energy level, but this is where much of the similarity ends.



Mixed Groups
The Carbon Group

- Carbon is a nonmetal, silicon and germanium are metalloids, and tin and lead are metals.



Mixed Groups
The Carbon Group

- Carbon occurs as an element in coal and as a compound in oil, natural gas, and foods.
- Carbon compounds, many of which are essential to life, can be found in you and all around you.

Mixed Groups
The Carbon Group

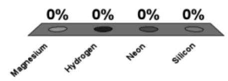
- Silicon is second only to oxygen in abundance in Earth's crust.
- The crystal structure of silicon dioxide is similar to the structure of diamond.
- Silicon occurs as two allotropes. **Allotropes,** which are different forms of the same element, have different molecular structures.

Mixed Groups
The Carbon Group

- Silicon is the main component in **semiconductors**—elements that conduct an electric current under certain conditions.
- Germanium, the other metalloid in the carbon group, is used along with silicon in making semiconductors.

Question 8: What is the main component in semiconductors?

1. Magnesium
2. Hydrogen
3. Neon
4. Silicon



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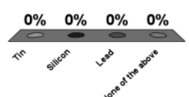
Mixed Groups
The Carbon Group

- Tin is used to coat other metals to prevent corrosion.
- Tin also is combined with other metals to produce bronze and pewter.
- Lead was used widely in paint at one time, but because it is toxic, lead no longer is used.

Question 9: ___ is used to coat other metals to prevent corrosion?

1. Tin
2. Silicon
3. Lead
4. None of the above



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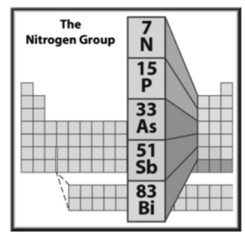
Mixed Groups
The Nitrogen Group

- The nitrogen family makes up Group 15.
- Each element has five electrons in its outer energy level.
- These elements tend to share electrons and to form covalent compounds with other elements.



Mixed Groups
The Nitrogen Group

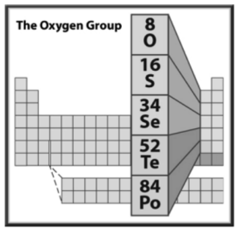
- Nitrogen is the fourth most abundant element in your body.
- Each breath you take is about 80 percent gaseous nitrogen in the form of diatomic molecules, N2.

Mixed Groups
Uses of the Nitrogen Group

- Phosphorus is a nonmetal that has three allotropes.
- Antimony is a metalloid, and bismuth is a metal.
- Both elements are used with other metals to lower their melting points.

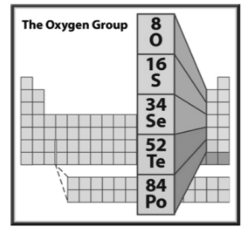
Mixed Groups
The Oxygen Group

- Group 16 on the periodic table is the oxygen group.
- Oxygen, a nonmetal, exists in the air as diatomic molecules, O2.



Mixed Groups
The Oxygen Group

- Group 16 on the periodic table is the oxygen group.
- Oxygen, a nonmetal, exists in the air as diatomic molecules, O2.
- During electrical storms, some oxygen molecules, O2, change into ozone molecules, O3.

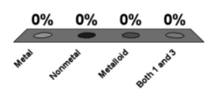


Mixed Groups
The Oxygen Group

- The second element in the oxygen group is sulfur.
- Sulfur is a nonmetal that exists in several allotropic forms.
- It exists as different-shaped crystals and as a noncrystalline solid.

Question 10: Sulfur is a ____?

1. Metal
2. Nonmetal
3. Metalloid
4. Both 1 and 3



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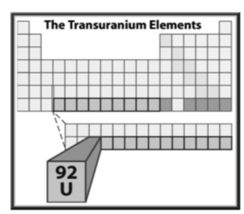
Mixed Groups
The Oxygen Group

- The nonmetal selenium and two metalloids—tellurium and polonium—are the other Group 16 elements.
- Selenium is the most common of these three.
- This element is one of several that you need in trace amounts in your diet.
- But selenium is toxic if too much of it gets into your system.

Mixed Groups
Transuranium Elements

- Elements having more than 92 protons, the atomic number of uranium, are called **transuranium elements**.
- These elements do not belong exclusively to the metal, nonmetal, or metalloid group.



Question 11: Elements having more than 92 protons, the atomic number of uranium, are called _____?

1. Conductors
2. Semiconductors
3. Metalloids
4. Transuranium elements

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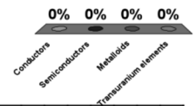

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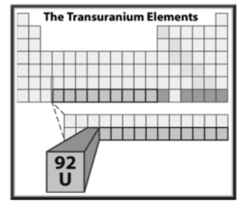
Mixed Groups

Transuranium Elements

- All of the transuranium elements are synthetic and unstable, and many of them disintegrate quickly.



Question 12: Transuranium elements are which of the following?

1. Unstable
2. Synthetic
3. And may disintegrate quickly
4. All of the above

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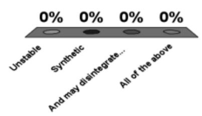

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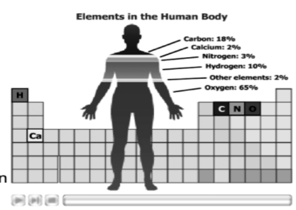
Lecture: Session 6

Elements and Their Properties
McLaughlin, C.W., Thompson, M. T., & Zike, D.(2010). *Tennessee Physical Science. McGraw-Hill, Inc.*

Nonmetals

Properties of Nonmetals

- Most of your body's mass is made of oxygen, carbon, hydrogen, and nitrogen.
- Calcium, a metal, and other elements make up the remaining four percent of your body's mass.
- Oxygen is the most abundant element in the body (65%)



Nonmetals

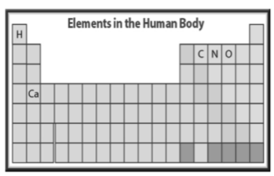
Properties of Nonmetals

- Phosphorus, sulfur, and chlorine are among these other elements found in your body.
- These elements are classified as nonmetals.
- **Nonmetals** are elements that usually are gases or brittle solids at room temperature.

Nonmetals

Properties of Nonmetals

- Most nonmetals do not conduct heat or electricity well, and generally they are not shiny.
- In the periodic table, all nonmetals except hydrogen are found at the right of the stair-step line.



Nonmetals

Properties of Nonmetals

- The noble gases, Group 18, make up the only group of elements that are all nonmetals.
- Group 17 elements, except for astatine, are also nonmetals.

Nonmetals

Bonding in Nonmetals

- The electrons in most nonmetals are strongly attracted to the nucleus of the atom. So, as a group, nonmetals are poor conductors of heat and electricity.
- Most nonmetals can form ionic and covalent compounds.

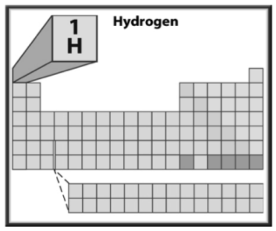
Nonmetals

Bonding in Nonmetals

- When nonmetals gain electrons from metals, the nonmetals become negative ions in ionic compounds.
- When bonded with other nonmetals, atoms of nonmetals usually share electrons to form covalent compounds.

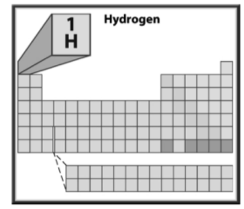
Nonmetals
Hydrogen

- If you could count all the atoms in the universe, you would find that about 90 percent of them are hydrogen.
- When water is broken down into its elements, hydrogen becomes a gas made up of diatomic molecules.



Nonmetals
Hydrogen

- A **diatomic molecule** consists of two atoms of the same element in a covalent bond.

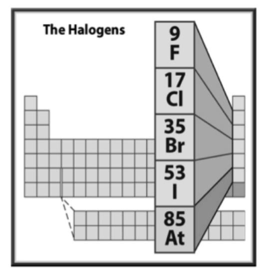


Nonmetals
Hydrogen

- Hydrogen is highly reactive.
- A hydrogen atom has a single electron, which the atom shares when it combines with other nonmetals.
- Hydrogen can gain an electron when it combines with alkali and alkaline earth metals.
- The compounds formed are hydrides.

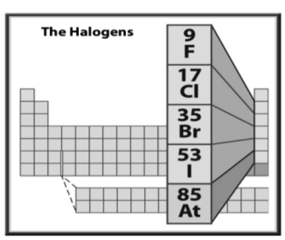
Nonmetals
The Halogens

- Halogen lights contain small amounts of bromine or iodine.
- These elements, as well as fluorine, chlorine, and astatine, are called halogens and are in Group 17.



Nonmetals
The Halogens

- They are very reactive in their elemental form, and their compounds have many uses.

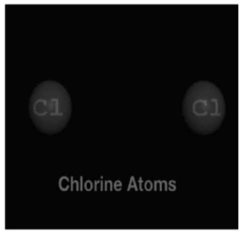


Nonmetals
The Halogens

- Because an atom of a halogen has seven electrons in its outer energy level, only one electron is needed to complete this energy level.
- If a halogen gains an electron from a metal, an ionic compound, called a **salt** is formed.

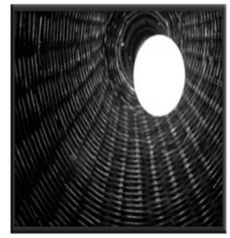
Nonmetals
The Halogens

- In the gaseous state, the halogens form reactive diatomic covalent molecules and can be identified by their distinctive colors.
- Chlorine is greenish yellow, bromine is reddish orange, and iodine is violet.



Nonmetals
The Halogens

- Fluorine is the most chemically active of all elements.
- Hydrofluoric acid, a mixture of hydrogen fluoride and water, is used to etch glass and to frost the inner surfaces of lightbulbs and is also used in the fabrication of semiconductors.



Nonmetals
Uses of Halogens

- Chlorine compounds are used to disinfect water.
- Chlorine, the most abundant halogen, is obtained from seawater at ocean-salt recovery sites.
- Household and industrial bleaches used to whiten flour, clothing, and paper also contain chlorine compounds.

Nonmetals
Uses of Halogens

- Bromine, the only nonmetal that is a liquid at room temperature, also is extracted from compounds in seawater.
- Bromine compounds are used as dyes in cosmetics.

Nonmetals
Uses of Halogens

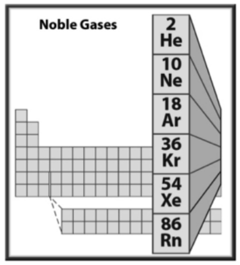
- Iodine, a shiny purple-gray solid at room temperature, is obtained from seawater.
- When heated, iodine changes directly to a purple vapor.
- The process of a solid changing directly to a vapor without forming a liquid is called **sublimation**.

Nonmetals
Uses of Halogens

- Astatine is the last member of Group 17. It is radioactive and rare, but has many properties similar to those of the other halogens.
- There are no known uses due to its rarity.

Nonmetals
The Noble Gases

- The noble gases exist as isolated atoms.
- They are stable because their outermost energy levels are full.
- No naturally occurring noble gas compounds are known.



Nonmetals
The Noble Gases

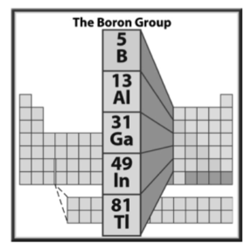
- The stability of noble gases is what makes them useful.
- The light weight of helium makes it useful in lighter-than-air blimps and balloons.
- Neon and argon are used in “neon lights” for advertising.

Mixed Groups
Properties of Metalloids

- Metalloids share unusual characteristics.
- **Metalloids** can form ionic and covalent bonds with other elements and can have metallic and nonmetallic properties.
- Some metalloids can conduct electricity better than most nonmetals, but not as well as some metals, giving them the name semiconductor.
- With the exception of aluminum, the metalloids are the elements in the periodic table that are located along the stair-step line.

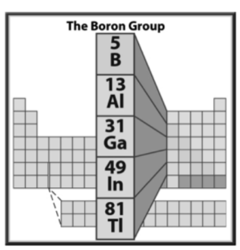
Mixed Groups
The Boron Group

- Boron, a metalloid, is the first element in Group 13.
- If you look around your home, you might find two compounds of boron.



Mixed Groups
The Boron Group

- One of these is borax, which is used in some laundry products to soften water.
- The other is boric acid, a mild antiseptic.

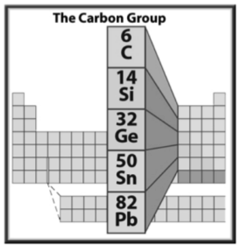


Mixed Groups
The Boron Group

- Aluminum, a metal in Group 13, is the most abundant metal in Earth’s crust.
- It is used in soft-drink cans, foil wrap, cooking pans, and as siding.
- Aluminum is strong and light and is used in the construction of airplanes.

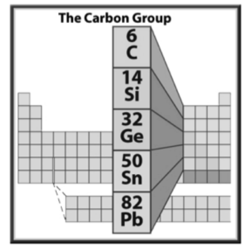
Mixed Groups
The Carbon Group

- Each element in Group 14, the carbon family, has four electrons in its outer energy level, but this is where much of the similarity ends.



Mixed Groups
The Carbon Group

- Carbon is a nonmetal, silicon and germanium are metalloids, and tin and lead are metals.



Mixed Groups
The Carbon Group

- Carbon occurs as an element in coal and as a compound in oil, natural gas, and foods.
- Carbon compounds, many of which are essential to life, can be found in you and all around you.

Mixed Groups
The Carbon Group

- Silicon is second only to oxygen in abundance in Earth's crust.
- The crystal structure of silicon dioxide is similar to the structure of diamond.
- Silicon occurs as two allotropes. **Allotropes,** which are different forms of the same element, have different molecular structures.

Mixed Groups
The Carbon Group

- Silicon is the main component in **semiconductors**—elements that conduct an electric current under certain conditions.
- Germanium, the other metalloid in the carbon group, is used along with silicon in making semiconductors.

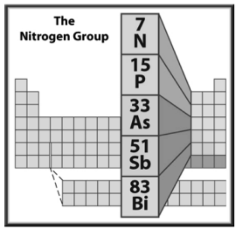
Mixed Groups
The Carbon Group

- Tin is used to coat other metals to prevent corrosion.
- Tin also is combined with other metals to produce bronze and pewter.
- Lead was used widely in paint at one time, but because it is toxic, lead no longer is used.

Mixed Groups

The Nitrogen Group

- The nitrogen family makes up Group 15.
- Each element has five electrons in its outer energy level.
- These elements tend to share electrons and to form covalent compounds with other elements.



Mixed Groups

The Nitrogen Group

- Nitrogen is the fourth most abundant element in your body.
- Each breath you take is about 80 percent gaseous nitrogen in the form of diatomic molecules, N2.

Mixed Groups

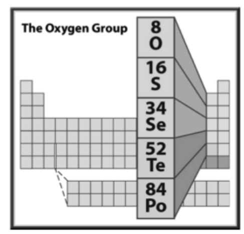
Uses of the Nitrogen Group

- Phosphorus is a nonmetal that has three allotropes.
- Antimony is a metalloid, and bismuth is a metal.
- Both elements are used with other metals to lower their melting points.

Mixed Groups

The Oxygen Group

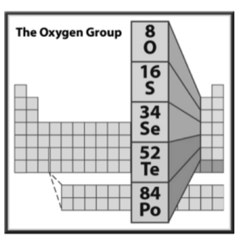
- Group 16 on the periodic table is the oxygen group.
- Oxygen, a nonmetal, exists in the air as diatomic molecules, O2.



Mixed Groups

The Oxygen Group

- Group 16 on the periodic table is the oxygen group.
- Oxygen, a nonmetal, exists in the air as diatomic molecules, O2.
- During electrical storms, some oxygen molecules, O2, change into ozone molecules, O3.



Mixed Groups

The Oxygen Group

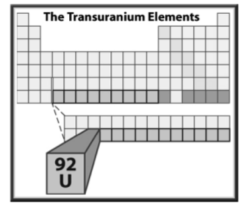
- The second element in the oxygen group is sulfur.
- Sulfur is a nonmetal that exists in several allotropic forms.
- It exists as different-shaped crystals and as a noncrystalline solid.

Mixed Groups
The Oxygen Group

- The nonmetal selenium and two metalloids—tellurium and polonium—are the other Group 16 elements.
- Selenium is the most common of these three.
- This element is one of several that you need in trace amounts in your diet.
- But selenium is toxic if too much of it gets into your system.

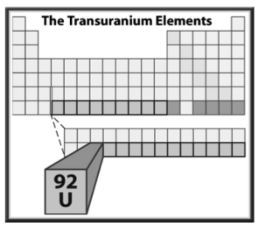
Mixed Groups
Transuranium Elements

- Elements having more than 92 protons, the atomic number of uranium, are called **transuranium elements**.
- These elements do not belong exclusively to the metal, nonmetal, or metalloid group.

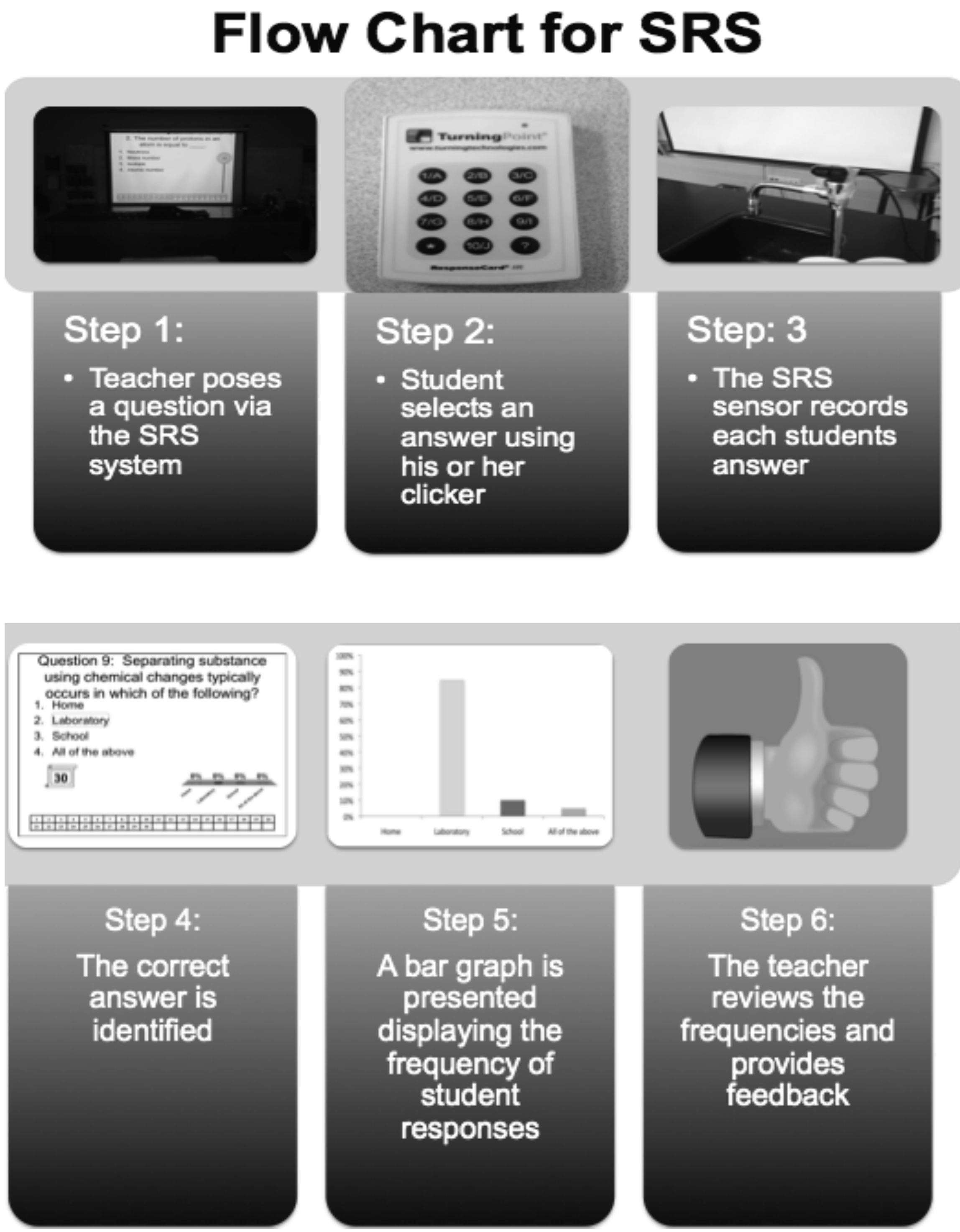


Mixed Groups
Transuranium Elements

- All of the transuranium elements are synthetic and unstable, and many of them disintegrate quickly.



Appendix F: Pictures of SRS



Appendix G: Pretest/Posttest:

Session 1

1. ____ is defined as anything that has mass and takes up space.

1. Matter
2. Gravity
3. Concepts
4. None of the above

2. Matter is made up of which of the following?

1. Pure substances
2. Mixtures
3. Both 1 and 2
4. None of the above

3. A type of matter with a fixed composition is a/an ____.

1. Pure substance
2. Mixture
3. Solution
4. All of the above

4. If all of the atoms in a substance have the same identity, that substance is a/an ___.

1. Atom
2. Compound
3. Element
4. None of the above

5. A _____ is a substance in which the atoms of two or more elements are combined in a fixed proportion.

1. Hydrogen
2. Compound
3. Element
4. Mixture

6. ____ is a material made up of two or more substances that can easily be separated by physical means.

1. Compound
2. Element
3. Heterogeneous mixture
4. Homogenous mixture

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
21	22	23	24	25	26	27	28	29	30										

7. A ___ contains two or more gaseous, liquid, or solid substances blended evenly throughout.

1. Compound
2. Element
3. Heterogeneous mixture
4. Homogeneous mixture

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
21	22	23	24	25	26	27	28	29	30										

8. Another name for a homogenous mixture is _____.

1. Compound
2. Suspension
3. Element
4. Solution

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
21	22	23	24	25	26	27	28	29	30										

9. ____ is a type of mixture with particles that are larger than those in solutions but not heavy enough to settle out.

1. Colloid
2. Suspension
3. Element
4. Compound

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
21	22	23	24	25	26	27	28	29	30										

10. _____ is a heterogeneous mixture containing a liquid in which visible particles settle.

1. Colloid
2. Suspension
3. Element
4. Compound

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
21	22	23	24	25	26	27	28	29	30										

Pretest/Posttest: Session 2

1. Any characteristic of a material that you can observe without changing the identity of the substance that make uo the material is a/an ____.

30

1. Physical property
2. Chemical property
3. Physical change
4. Chemical change

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
21	22	23	24	25	26	27	28	29	30										

2. Which of the following is an example of a physical property?

30

1. Color
2. Shape
3. Size
4. All of the above

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
21	22	23	24	25	26	27	28	29	30										

3. A change in size, shape, or state of matter is a/an ___.

30

1. Physical property
2. Chemical property
3. Physical change
4. Chemical change

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
21	22	23	24	25	26	27	28	29	30										

4. Which of the following is an example of a physical change?

30

1. Tearing paper
2. Burning wood
3. Rusting metal
4. Both 1 and 3

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
21	22	23	24	25	26	27	28	29	30										

5. When freezing water, what type of change occurs?

30

1. Physical property
2. Chemical property
3. Physical change
4. Chemical change

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
21	22	23	24	25	26	27	28	29	30										

6. _____ is a characteristic of a substance that indicates whether it can undergo a certain chemical change.

1. Physical property
2. Chemical property
3. Physical change
4. Chemical change

30

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
21	22	23	24	25	26	27	28	29	30										

7. Which of the following is an example of a chemical property?

1. Flammable liquids
2. Color
3. Size
4. Shape

30

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
21	22	23	24	25	26	27	28	29	30										

8. A change from one substance to another is ____.

1. Physical property
2. Chemical property
3. Physical change
4. Chemical change

30

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
21	22	23	24	25	26	27	28	29	30										

9. Which of the following is an example of a chemical change?

1. Burning wood
2. Metal rusting
3. Foaming of an antacid tablet
4. All of the above

30

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
21	22	23	24	25	26	27	28	29	30										

10. The law of conservation of mass states that mass can be created or ____.

1. Made
2. Destroyed
3. Changed
4. None of the above

30

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
21	22	23	24	25	26	27	28	29	30										

Pretest/Posttest: Session 3

1. What do scientists uses to communicate so that all scientists understand?

1. English
2. Scientific Method
3. Scientific shorthand
4. None of the above

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
21	22	23	24	25	26	27	28	29	30										

2. ____ is the smallest piece of matter that still retains the properties of the element.

1. Molecule
2. Element
3. Atom
4. Compound

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
21	22	23	24	25	26	27	28	29	30										

3. The center of an atom that contains protons and neutrons is a/an ___.

1. Core
2. Nucleus
3. Cloud
4. Quark

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
21	22	23	24	25	26	27	28	29	30										

4. The positively charged particle that is located in the nucleus of an atom is a/an ___.

1. Electron
2. Neutron
3. Atom
4. Proton

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
21	22	23	24	25	26	27	28	29	30										

5. _____ is the neutral particle that is located inside the nucleus.

1. Electron
2. Neutron
3. Atom
4. Proton

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
21	22	23	24	25	26	27	28	29	30										

6. ____ is a tiny negative charged particle that floats around the outside of a nucleus.

1. Electron
2. Neutron
3. Atom
4. Proton

30

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
21	22	23	24	25	26	27	28	29	30										

7. Which of the following are examples of the atomic model?

1. Electron cloud model
2. Rutherford model
3. Bohr model
4. All of the above

30

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
21	22	23	24	25	26	27	28	29	30										

8. Which atomic model is the most current?

1. Electron cloud model
2. Rutherford model
3. Bohr model
4. Thomson model

30

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
21	22	23	24	25	26	27	28	29	30										

9. Electrons are located in a/an _____.

1. Electron cloud
2. Nucleus
3. Satellite
4. Quark

30

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
21	22	23	24	25	26	27	28	29	30										

10. How many electrons are in the third energy level in the electron cloud?

1. 20
2. 2
3. 18
4. 8

30

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
21	22	23	24	25	26	27	28	29	30										

1. The unit of measurement used for atomic particles is the _____.

1. Atomic mass unit (amu)
2. Nucleus mass unit (nmu)
3. Atomic matter count (amc)
4. None of the above

2. The number of protons in an atom is equal to ____.

1. Neutrons
2. Mass number
3. Isotope
4. Atomic number

3. ____ is the sum of the number of protons and the number of the neutrons in the nucleus of an atom.

1. Quark
2. Electron
3. Mass number
4. Atomic number

4. How many groups are located on the periodic table?

1. 15
2. 4
3. 10
4. 18

5. How may valence electrons does group 18 have?

1. 4
2. 6
3. 8
4. 10

6. According to the periodic table, what is Lithium's atomic number?

1. 1
2. 3
3. 5
4. 6

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
21	22	23	24	25	26	27	28	29	30										

7. According to the periodic table, how many protons does Lithium have?

1. 3
2. 7
3. 4
4. 35

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
21	22	23	24	25	26	27	28	29	30										

8. According to the periodic table, what is the mass number of Potassium?

1. 47
2. 39
3. 12
4. 32

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
21	22	23	24	25	26	27	28	29	30										

9. How many regions are on the periodic table?

1. 5
2. 8
3. 3
4. 10

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
21	22	23	24	25	26	27	28	29	30										

10. According to the periodic table, Lithium is a ____.

1. Metal
2. Nonmetal
3. Metalloid
4. None of the above

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
21	22	23	24	25	26	27	28	29	30										

1. Metals reflect light. This property is called ____.

30

1. Luster
2. Shiny
3. Dull
4. Dim

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
21	22	23	24	25	26	27	28	29	30										

2. Metals can be hammered or rolled into sheets. This property is called ___.

30

1. Ductile
2. Shiny
3. Malleable
4. None of the above

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
21	22	23	24	25	26	27	28	29	30										

3. Which of the following explains why when a metal is hammered into sheets or drawn into wires, it dos not break.

30

1. Ionic bonding
2. Metallic bonding
3. Covalent bonding
4. None of the above

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
21	22	23	24	25	26	27	28	29	30										

4. Which of the following is the most reactive of all of the metals?

30

1. Transition
2. Alkali
3. Alkaline Earth Metals
4. None of the above

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
21	22	23	24	25	26	27	28	29	30										

5. ____ is one in which the nucleus breaks down and gives off particles of energy.

30

1. Radioactive elements
2. Transition element
3. Alkali metals
4. None of the above

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
21	22	23	24	25	26	27	28	29	30										

6. ____ helps makes your bones strong.

1. Calcium phosphate
2. Magnesium
3. Oxygen
4. Phosphorus

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
21	22	23	24	25	26	27	28	29	30										

7. ____ is the main component of steel is the most widely used of all the metals.

1. Tin
2. Neon
3. Concrete
4. Iron

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
21	22	23	24	25	26	27	28	29	30										

8. Which of the following metals were once used to make coins?

1. Copper
2. Silver
3. Gold
4. All of the above

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
21	22	23	24	25	26	27	28	29	30										

9. The two rows of elements that seem to be disconnected from the rest of the periodic table are called ___.

1. Between transition elements
2. Inner transition elements
3. Central transition elements
4. None of the above

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
21	22	23	24	25	26	27	28	29	30										

10. Metals in the Earth's curst that combine with other elements are found as ___.

1. Metalloids
2. Liquids
3. Gasses
4. Ores

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
21	22	23	24	25	26	27	28	29	30										

1. ____ is the most abundant element in the human body.

30

1. Oxygen
2. Phosphorus
3. Lithium
4. Magnesium

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
21	22	23	24	25	26	27	28	29	30										

2. Which of the following do not conduct heat well, and are generally not shiny?

30

1. Metals
2. Metalloids
3. Nonmetals
4. Both 1 and 2

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
21	22	23	24	25	26	27	28	29	30										

3. _____ is the most chemically active of all elements.

30

1. Hydrogen
2. Fluorine
3. Calcium
4. Silcon

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
21	22	23	24	25	26	27	28	29	30										

4. ____ are considered semiconductors.

30

1. Metals
2. Metalloids
3. Nonmetals
4. None of the above

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
21	22	23	24	25	26	27	28	29	30										

5. ____ is the only nonmetal that is a liquid at room temperature.

30

1. Bromine
2. Lead
3. Fluorine
4. Aluminum

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
21	22	23	24	25	26	27	28	29	30										

6. Which of following is the most abundant metal in the earth's crust?

30

1. Aluminum
2. Carbon
3. Oxygen
4. Phosphorus

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
21	22	23	24	25	26	27	28	29	30										

7. Which element is no longer used in paint because it is toxic?

30

1. Tin
2. Neon
3. Silicon
4. Lead

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
21	22	23	24	25	26	27	28	29	30										

8. ___ are elements that conduct electric current under certain conditions.

30

1. Conductors
2. Semiconductors
3. Metal
4. All of the above

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
21	22	23	24	25	26	27	28	29	30										

9. Oxygen is considered a _____?

30

1. Metal
2. Nonmetal
3. Metalloid
4. Both 2 and 3

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
21	22	23	24	25	26	27	28	29	30										

10. Transuranium elements can be a member of which of the following group?

30

1. Metal
2. Nonmetal
3. Metalloid
4. All of the above

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
21	22	23	24	25	26	27	28	29	30										

Appendix H: Demographics Questionnaire

Please answer the following questions.

Gender: Male or Female
Ethnicity: Asian American African American Caucasian Hispanic Other
Current Grade:
Age:

Appendix I: Social Validity Questionnaire

Please circle the most appropriate answer.

1. I enjoyed using the clickers during my physical science class. Strongly Disagree   Disagree   Neither Agree nor Disagree   Agree   Strongly Agree
2. I feel that I was more focused on the material during the lectures in which I used a clicker. Strongly Disagree   Disagree   Neither Agree nor Disagree   Agree   Strongly Agree
3. I feel that my quiz score were higher following the lecture that I used a clicker. Strongly Disagree   Disagree   Neither Agree nor Disagree   Agree   Strongly Agree
4. I would recommend using clickers for this class in the future. Strongly Disagree   Disagree   Neither Agree nor Disagree   Agree   Strongly Agree

Appendix J: Treatment Integrity Checklist

Treatment Integrity Checklist (Clicker)						
Class period	Day 1 Group 1	Day 3 Group 1	Day 5 Group 1	Day 2 Group 2	Day 4 Group 2	Day 6 Group 2
Each lecture is in PowerPoint format						
Each lecture (treatment day) has 12 interactive questions						
Each pretest and posttest have identical questions						
Announce questions will be held until the end of class (after the posttest)						
Ensure each student has a clicker						
Ensure each clicker is properly working						
Complete the class in the same order (demographics (day 1 only), pretest, lecture, posttest, social validity (day 6 only)						
Verbally cover all material on each slide						
Allow 30 for each question pretest, posttest, or interactive question						
Do not cover any additional information						
Total=						

Treatment Integrity Checklist (No Clicker)						
Class period	Day 2 Group 1	Day 4 Group 1	Day 6 Group 1	Day 1 Group 2	Day 3 Group 2	Day 5 Group 2
Each lecture is in PowerPoint format						
Each lecture does not include interactive questions						
Each pretest and posttest have identical questions						
Announce questions will be held until the end of class (after the posttest)						
Ensure each student has a clicker						
Ensure each clicker is properly working						
Complete the class in the same order (demographics (day 1 only), pretest, lecture, posttest, social validity (day 6 only)						
Verbally cover all material on each slide						
Allow 30 for each question pretest, posttest, or interactive question						
Do not cover any additional information						
Total=						

Appendix K: Individual Change Scores: Non-Inclusive

	Sessions						Overall Change Score	
Student	1*	2	3*	4	5*	6	SRS*	Lecture
1	0	2	6	2	4	2	10	6
2	2	1	4	4	2	2	8	7
3	4	-1	3	2	4		11	1
4	5	1	3	5			8	6
5	0	1	0	4	5	2	5	7
6	0	0	2	0	6	2	8	2
7	-1	4	4	0	6	6	9	10
8	4		1	2	5	2	10	4
9	2	1	1	3	6	2	9	6
10	5	1	5	0	4	3	14	4
11	2	2	5	-1	0	4	7	5
12	-1	2	0	2	5	5	4	9
13	0	3	4	1	2	-1	6	3
14	3	2	6	1		0	9	3
15	4	1	6	4	6	6	16	11
16	3	-1	1	1	3	3	7	3
17	-1	1	4	2	7	4	10	7
18	4	0	2	1	4	-1	10	0
19	2	8	7	1	3	3	12	12
20	3		0	2	4	3	7	5
21	1	2	2	3	5	3	8	8
22	1	3	6		4	1	11	4
23	4	2	0	2	4	2	8	6
24	2	2	5		0	1	7	3
25	2	0	4	5	5	3	11	8
26	-2	2	1	1	5	1	4	4
27		3	2	3	3	2	5	8
28	3	2	-1	4	4	1	6	7
29	0	2	6	0	2	2	8	4

Note. Blank cells indicate the student did not participate during that session.

Individual Change Scores: Inclusive

	Sessions						Overall Change Score	
Student	1	2*	3	4*	5	6*	Lecture	SRS*
1	-2	2	4	0	2	0	4	2
2	-1	1	3	3	0	2	2	6
3	0	3	3	3	2	1	5	7
4	4	3	4	4	6	6	14	13
5	-1	0		1	4	5	3	6
6	3	-1	-2	3	4	0	5	2
7	4	-2	4	3	3	-1	11	0
8	3	-4	6	3	2	1	11	0
9	5	-2	1	2	1	1	7	1
10	3	0	5	3	-1	1	7	4
11	2	1	1	4	5	4	8	9
12	2	3	6	-1	0	1	8	3
13	4	-1	6	6	3	1	13	6
14	2	-1	5	1		1	7	1
15	6	3	5	2	5	5	16	10
16	2	-1	-2	-2		-1	0	-5
17	1	0	0	2	2	-1	3	1
18	3	2	6	1	3	1	12	4
19		1	0	1	2	-1	2	1
20	4	0		1	3	4	7	5
21	3	3	3		-1		5	3
22		3	1		1	3	2	6
23	2	0	2	2	5	3	9	5
24	3	2	5	1	2	0	10	3
25	0	-2	-1	2	-1	0	-2	0
26	1	2	4	2	0	0	5	4
27	1	2	3		0	0	4	2
28	1		3		0	1	4	1
29	3	-1	3	2	0		6	1

Note. Blank cells indicate the student did not participate during that session.