WORKING SMARTER NOT HARDER: INCLUSIVE LESSONS FOR MIDDLE SCHOOL SCIENCE

by

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Abstract

Classrooms are becoming increasingly diverse and the need for effective inclusive strategies is becoming more pronounced. Including students with exceptionalities into general classrooms is becoming the norm, however effective strategies are necessary to facilitate meaningful inclusion rather than superficial sharing of space. This need is especially true in content areas such as science. In these classes, students with exceptionalities tend to complete alternative programs in a resource room or have poor learning experiences in class. This project contains a content analysis of inclusive strategies and presents inclusive teaching resources that can help inclusion in middle school science classes. The strategies surveyed are research-based strategies that a teacher can implement in a general middle school science class. The strategies include technology, collaboration, universal design for learning (UDL), differentiated instruction (DI), strategy instruction, peer assisted learning, behaviour supports, and teacher practices. The strategies were analysed from the point of view of a learning support and science teacher for effectiveness in a middle school science class. A directed literature review was completed to more deeply examine strategies chosen for the teaching resources. Teaching resources were created and included with this project. The teaching resources were designed using universal design for learning (UDL) and other strategies from the content analysis.

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Part One: Introduction

Over the last few decades, there has been a shift towards increasing access for all students to the general classroom (Wehmeyer, 2014). Students with exceptionalities are generally included in the general classroom but inclusion is more than having learners in the same space as it involves providing meaningful access to learning for all. As Sebba and Ainscow (1996) remind us, the underlying tenant of inclusion is the development of schools focused on understanding and educating all students; allowing every student to develop according to their abilities, skills and talents. Educators must be mindful when supporting students with exceptionalities in their classes. Are we providing meaningful access for all students? How can we improve the educational experience of all students? The answers to these questions may be found within the ideas of inclusion. Inclusion involves access to relevant, engaging educational experiences in an environment that values and respects individual differences (Waitoller & Artiles, 2013). Questions around how to support students and facilitate inclusion in class led to the research question for this project. What are some research based inclusive strategies that can be used in a middle school science class? The purpose of this project is to find and showcase research supported strategies that can help facilitate inclusion in a middle school science class.

Research has shown that there are benefits of inclusion for students with disabilities (Alquraini & Gut, 2012; Carter et al., 2007; Copeland et al., 2004; Ryndak & Billingsley, 2004) as well as general education students (Bradley, 2016; Morningstar et al., 2015). This means that, when done properly including learners with exceptionalities in general classes can benefit all students. Unfortunately, some classrooms include students with exceptionalities without proper resources or teacher training, which does not necessarily facilitate inclusion (Salend & Duhaney, 2011; Tremblay, 2013; Worrell, 2008). The benefits of inclusion are not simply a function of location (Browder & Spooner, 2006). It has been found that educational quality is far more important than location (Terzi, 2014). Including exceptional students without proper supports can occur at the expense of quality instruction for others (Kauffman et al., 2005). Educating students in the same space without appropriate learning activities or supports is not inclusion and can result in negative experiences (Kauffman et al., 2005). Unfortunately, some educators tasked with making inclusion work lack sufficient training (Dieker, 2007; Horrocks et al., 2008; Kuntz & Carter, 2019). These teachers may struggle to provide supports that promote student access and progress in the curriculum (Lee et al., 2010). Researchers, such as Salend and Duhaney (2011), emphasize that inclusive education benefits students with and without disabilities, but only when teachers use effective, high-quality strategies and supports. The aim of this project is to review and showcase some of these supports.

Elementary levels have seen greater success with inclusion than at the middle and secondary levels (Kozik et al., 2009; Bender et al., 2008). In higher levels, middle and high school levels, students with low incidence disabilities or exceptionalities still tend to be educated in segregated special education classes and may not take middle and high school content area classes such as science, math, English and socials (Fox & Ysseldyke, 1997). Furthermore, students who have high incidence disabilities, lower achievement, lower executive functioning (EF) skills, or lower identification with academics can struggle with secondary level content area classes (Denckla, 2007). These are all forms of exclusion, as the lack of participation or success of these students reveals a lack of access or a barrier to learning. Inclusion at higher levels poses many challenges including high pacing and complex content (Kozik et al., 2009; Mastropieri & Scruggs, 2001). Other challenges to inclusion include, expectations that are beyond students EF and academic skills (Meltzer & Krishnan, 2007; Samuels et al., 2016; Waber et al., 2006), negative teacher attitudes, limited inclusive strategies, and poor teacher collaboration (Worrell, 2008). Teachers tend to use more inclusive strategies when their attitudes towards inclusion becomes more positive (Lyons et al., 2016). However, addressing teachers' negative attitudes may be a more effective intervention for elementary grades as in middle and high school grades addressing attitudes alone did not result in increased use of inclusive practices (Bender et al.,2008). Research-based supports and strategies can increase inclusion of students with disabilities at higher grades (Kuntz & Carter, 2019). To increase inclusion additional professional development and training on effective inclusion strategies may be necessary for middle and high school teachers to facilitate inclusion (Bender et al., 2008; Mastropieri & Scruggs 2001; Terzi, 2014). As schools become more inclusive, students with a wider range of abilities are learning together, yet, to increase access and make learning meaningful, teachers need to be mindful and be using effective inclusive strategies.

Personal Location

This project is important to me as a Learning Support (LST) and science teacher, as I have worked as a *pull-out* resource type teacher, a *push in* co-teacher, and a solo science teacher. In these roles, I have seen great strides being made towards inclusion as well as areas where improvements could be made. I feel it is important that all students need access to learning that is interesting, respectful, meets them where they are and helps them develop, values who they are, and helps them feel socially included. For some this may be support with academic skills, such as reading, writing and numeracy, for others this may be support with (EF) skills such as attention, self-regulation. By completing the content analysis and creating the associated resources, I have increased my knowledge in inclusive strategies and I am better prepared to implement strategies within my class and to help other teachers to do the same.

As a researcher and teacher, I have a vested interest in supporting inclusion. I am hoping to use the resources package created in this master's project at my school and plan to give it to my colleagues. I also have a professional goal of facilitating inclusive practices and increasing accessibility for all students. I believe it is important to use strategies that can help all students in class. As an LST, I have often referred students for academic screening to determine if they are performing at grade level in academic skills. I find that students who perform at grade level during assessments are not yet successful in the general classroom. We do not always know why a student is struggling with learning in the classroom and many struggling students do not have a designation to qualify them for extra supports. Because of this, I believe that all learners must have access to inclusive learning strategies and activities that help them develop. To do this, I believe a teacher must provide varied supports and learning opportunities that are inclusive and accessible for all students.

Significance of the Project

The research question for this project was, what are some research based inclusive strategies that can be use in a middle school science class? This project used a content analysis to review effective inclusive strategies for middle school science classes. The strategies were reviewed from the perspective of a learning support and science teacher to determine if they would be effective in a middle school science class. Universal design for learning (UDL) with a focus on (EF) supports were chosen based on findings from the content analysis. These inclusive strategies were further explored with a directed literature review. The strategies were then used to create resources for a middle school science class. This project is ontologically rooted in postmodern relativism; that truth is built based on experience (Mayan, 2009). I believe there is no one truth or reality for all teachers. The intention of the project is to encourage teachers to engage with inclusive practices and develop strategies that fit with their pedagogy and needs. The resources presented are meant as a starting point to help teachers develop confidence with, and knowledge of, inclusive strategies in middle school science.

The project surveyed and presented inclusive strategies found during the content analysis. This project is strategic in nature. The purpose of strategic research is not only to gain understanding on the topic of research but also to affect change and influence current thinking (Spradley, 1979). The project helped me to gain knowledge in facilitating inclusive strategies in middle school science but will also influence the practices of middle and secondary level science teachers in my school district by providing them with resources. This significance of this project provides resources to middle and secondary science teachers to facilitate inclusive practices in their science class; a subject area that has traditionally struggled with inclusion (Bender et al., 2008; Fox & Ysseldyke, 1997; Kozik et al., 2009; Ness, 2007). Providing access to meaningful learning experiences for all students can be a daunting task, thus, this project was completed to help middle school science teachers as they work towards facilitating inclusion.

Background of the Project

I have been working as the (LST) at a middle school for two years and taught secondary science for five years. I have seen the need for inclusive resources especially the middle and high school level science classes. I also see the opportunity to use inclusive strategies and develop the skills, materials, and resources in middle and secondary school science that could eventually be used district wide to support inclusion.

It is important to have a working definition of inclusion to promote inclusion. Inclusion involves dismantling barriers for learning and participation (Waitoller & Artiles, 2013), which is more than supporting students with physical and cognitive disabilities. Inclusion involves providing access to meaningful educational experiences for all (Moore, 2016). Meaningful educational experiences are engaging and relevant to the learner, they meet learners where they are and help them develop. Meaningful educational experiences value diversity and students' strengths. Inclusion is the redistribution of access to quality learning. The valuing of student differences in content, pedagogy and assessment involves creating opportunities for nondominant groups to have a voice regarding solutions to minimize their exclusion (Waitoller & Artiles, 2013). Inclusion, as described here, is an ambitious goal, however it is attainable as teachers increase their knowledge and confidence in using inclusive strategies.

In my school district, I have noticed that inclusive classrooms are common in elementary schools. However, as students enter grade 8, those with low incidence or significant disabilities tend to attend resource type programs. In my experience, these resource programs support these students in a traditional segregated model. Most of the students in resource type programs may never take upper level science classes in high school or have access to the curriculum, skills and processes that are found within these courses. Although it may not be appropriate for all students to take all courses, all students should have the opportunity to access them. From what I have observed, students in resource type programs do not enroll into higher level science classes in K-12 schools. As Shelley Moore (2018) reminds us, the big ideas and general knowledge gleaned from these classes can be useful and interesting for all. Many of students will never become chemists or engineers after high school but there is still value for all students to learn about science.

My school district is predominantly composed of high schools and elementary schools, but the school I work at is the one exception. I work at the only middle school in my school district, with students in grade 6-9. The goal of our middle school is to support all students at this neighborhood school in meaningful learning programs with their peers. Our students with low incidence designations or very high needs are kept in general classes at our middle school rather than going to specialized resource type programs. From what I observed in my school, some of the grade 8 and 9 teachers seem to be unsure of how to meet the needs of students who have significant exceptionalities, therefore some these students can struggle with learning in their classes. The need for effective inclusive strategies, like ones presented in this project, to support the learning needs of students with exceptionalities in middle school science classes.

Literature Review

Universal design for learning (UDL) and executive functioning skills (EF) were explored in a literature review. It was important to describe UDL and EF at this point of the project to give a foundation to the discussion to come. UDL was identified as the main inclusive strategy based on the findings from the content analysis. UDL with a focus on EF are used in the associated resources at the end of this project.

Universal Design for Learning (UDL)

UDL is an inclusive planning and instructional framework. It has been developed from a broad base of research on brain-based learning and effective teaching practices which allows both to be embedded into teaching practice (Meyer et al., 2014). UDL is based on three underlying principles of providing: (1) multiple means of engagement, (2) multiple means of representation, and (3) multiple means of action and expression. Within the key principles are nine guidelines separated into checkpoints that help teachers shape instructional goals, assessments, methods, and materials (Table 1). Planning using UDL reduces barriers to learning and gives maximum opportunity to build knowledge (Capp, 2017; Courey et al., 2012). Rather than targeting average students and then providing extensions for the high achievers and reductions for the struggling students, the goal is to proactively design a flexible classroom from predicted ranges of variability in learners. UDL emphasizes importance of planning to assume and plan for the natural variability of diverse learners as well as learning goals specific to the lesson (Meyer et al., 2014). The intention of UDL is to design accessible content and learning environments to improve the learning experience of all students regardless of learning abilities.

Table 1

Universal Design for Learning Guidelines

Principles	**Provide multiple means of Representation**	**Provide multiple means of Action and Expression**	**Provide multiple means of Engagement**
Guidelines and Checkpoints	Provide options for perception: Offer ways of customizing the display of information. Offer alternatives for auditory information. Offer alternatives for visual information.	Provide options for physical action: Vary the methods for response and navigation. Optimize access to tools and assistive technologies.	Provide options for recruiting interest: Optimize individual choice and autonomy. Optimize relevance, value, and authenticity. Minimize threats and distractions.
	Provide options for language and symbols: Clarify vocabulary and symbols. Clarify syntax and structure. Support decoding of text, mathematical notation, and symbols. Promote understanding across languages. Illustrate through multiple media.	Provide options for expression and communication: Use multiple media for communication. Use multiple tools for construction and composition. Build fluencies with graduated levels of support for practice and performance	Provide options for sustaining effort and persistence: Heighten salience of goals and objectives. Vary demands and resources to optimize challenge. Foster collaboration and community. Increase mastery-oriented feedback.
	Provide options for comprehension: Activate or supply background knowledge. Highlight patterns, critical features, big ideas, and relationships. Guide information processing and visualization. Maximize transfer and generalization.	Provide options for executive functions: Guide appropriate goal setting. Support planning and strategy development. Facilitate managing information and resources. Enhance capacity for monitoring progress.	Provide options for self-regulation: Promote expectations and beliefs that optimize motivation. Facilitate personal coping skills and strategies. Develop self-assessment and reflection.

Adapted from Meyer et al., (2014)

UDL is a powerful tool for inclusion. If properly used, UDL has the potential to support all learners within the general classroom (Capp, 2017; Hitchcock et al., 2016; Morningstar et al., 2015; Rappolt-Schlichtmann et al., 2013). UDL can actively engage learners increasing their participation and learning (Dieker, 2007). UDL is an efficient approach for designing flexible, accessible learning environments that can match a wide range of learner needs, abilities, background knowledge, educational experience, and cultural differences (Al-Azawei et al., 2016). Although UDL is not a simple strategy to implement, research has shown that relatively simple training in UDL can help teachers to design inclusive lesson plans (Courey et al., 2012; Spooner et al., 2007). Lesson planning with UDL enables teachers to support students more effectively by planning for variability within, while increasing engagement and learning (Brownlie et al., 2011; Meyer et al., 2016).

Executive Functioning (EF)

EF is an umbrella term for the cognitive processes associated with attention, goal setting, organization, information processing and self-regulation (Barkley, 2012; Cooper-Khan & Foster, 2013). EF has been found to be very important in school (Anderson et al., 2002; Berninger et al., 2017) and has been linked with school success (Denckla, 2007; Diamond & Lee, 2011; Samuels et al., 2016; Thorell et al., 2009; Waber et al., 2006). Students with poor EF skills often struggle with the demands of middle and high school classes (Denckla, 2007). In middle and high schools, there are increased demands for paying attention, completing tasks, self-regulating and staying organized (Denckla, 2007). Having poor EF skills can be a barrier for students to access learning. By supporting and developing students' EF, a teacher can reduce barriers to learning and help facilitate an inclusive learning environment.

EF challenges can be found in many students such as: students with learning disabilities (Meltzer & Krishnan, 2007; Stein & Krishnan, 2007), ADHD (Barkley, 2016; Denckla, 2007; DuPaul et al., 2012; Hinshaw et al., 2007; Nigg & Casey, 2005; Pennington, 1991) and autism (Ozonoff & Schetter, 2007; Robinson et al., 2009). Children who have experienced trauma are more likely to struggle with EF which can contribute to academic and behavioral problems

(DePrince, et al., 2009; Lansdown et al., 2007). Socioeconomic status (SES) also has a measurable negative impact on EF (Clavo & Bialystok, 2015), with poverty being associated with markedly lower EF (Farah, et al., 2006). Low EF and low SES together are more strongly associated with negative physical and psychological health than low SES alone (Kim et al., 2013). EF challenges can also be seen in students who do not have disabilities or diagnosed challenges (Anderson, 2002; Barkey, 2012; Best et al., 2009; Samuels et al., 2016). It is my experience that any student who has difficulty with planning, organizing, staying on task, completing assignments, or self-regulation, can benefit from development of EF skills.

If EF deficits are not remediated, they can persist into adolescence and adulthood (Barkley, 2016; Kim et al., 2013; Hinshaw et al., 2007). Students who were succeeding in elementary school can struggle in higher grades because of the increased EF demands in middle and high school (Denckla, 2007). Compared to elementary school, in middle and high school, there are increased expectations of independence, responsibility, planning, and organisation (Denckla, 2007). This jump in expectations can be a major barrier for learning for many students and may lead to students with EF challenges being mislabelled as lazy, unmotivated, or irresponsible rather than as being neurodevelopmentally less mature (Denckla, 2007). There are many challenges for students struggling with EF, however, research also indicates that EF can increase during adolescence (Diamond & Lee, 2011; DuPaul et al., 2012; DuPaul & Weyandt, 2006; Gaskins & Pressley, 2007; Jacob & Parkinson, 2015; Samuels et al., 2016). Therefore, implementing EF strategies and supports can be important for middle school students.

Middle school is an ideal time to support students in developing EF skills. EF development begins during infancy and continues into the fourth decade (Anderson, 2002; Denckla, 2007). Late maturity of EF is evidenced by neuroimaging studies that show the brain regions associated with EF can continue to develop into the teen years any beyond (Diamond, 2000). As EF is developing, it has been found to be very vulnerable to stressors (Best et al., 2009; Casey et al., 2000), conversely it has also been found to improve when targeted with interventions (Diamond & Lee, 2011; Holmes et al., 2009; Thorell et al., 2009) especially for populations of students with exceptionalities (Berninger et al., 2017; Humphries et al., 2004; Melter & Krishnan, 2007; Robinson et al., 2009). Interventions to develop EF could help many students and could help close the achievement gap between learners with different levels of socioeconomic status (Diamond & Lee, 2011). Interventions may also help avoid negative impacts on students' self-concept (Thompson, 1997). Many middle and high school students, including some of our most vulnerable populations, can benefit from EF supports and development (Diamond & Lee, 2011; DuPaul et al., 2012; DuPaul & Weyandt, 2006; Gaskins & Pressley, 2007; Jacob & Parkinson, 2015; Samuels et al., 2016).

Part Two: Content Analysis

A content analysis was conducted to highlight strategies to support inclusion in middle school science, then a directed literature review was completed to further explore strategies identified for the inclusive resources for middle school science teachers. To add clarity and validity, variables were operationalized with clear definitions to use throughout the content analysis. Inclusion was defined as meaningful access to the general classroom for all students including students with low incidence disabilities, high incidence disabilities, and students with behavioural challenges. Not only does inclusion include physical presence in the general classroom, but it also includes relevant and appropriate learning activities and learning goals. I defined best practice strategies as strategies, based in research, that the general education teacher could employ in their class. For this review, strategies outside the realm of the classroom were excluded, such as interventions occurring outside of school or in specialized programs, school culture initiatives and school-wide interventions and administrative strategies. Although these factors may be very important, they are beyond the scope of this project.

The purpose of this content analysis was to highlight effective inclusive strategies for middle school science. Strategies were presented based on prevalence and analyzed primarily by how a science and learning support teacher who identified their usefulness to a middle school science class. This means that the content analysis is biased towards my opinions and preferences. The purpose of this project is not to identify that the most effective strategy because the experiences and realities of each teacher differ. Instead, the aim of this project is to discuss research-based inclusive strategies that may be effective in a middle school science class. Then this project concludes by presenting resources created that use inclusive strategies in middle school science for teachers to access and develop their own inclusive practices.

Research Design

The goal of the content analysis was to review and present inclusive, research-based strategies for use in middle school science classes. The data collected were peer reviewed scholarly journals available online from the University of Northern British Columbia (UNBC) library website. The aim was to review the entire article for inclusive strategies, therefore entire article had to be available online. The following databases were searched: Academic Search Complete, Education Resources Information Center (ERIC), and Teacher Reference Center. Purposeful sampling was used to increase qualitative rigor and applicability to the research question (Mayan, 2009). Purposeful sampling is identifying sampling criteria prior to conducting research for the most effective use of resources (Mayan, 2009). Inclusion criteria included: focusing on inclusive strategies for students with disabilities, being peer reviewed, available online, written in English, published between 2000 and 2019, and containing strategies applicable to a middle school general science class. The following search string was used to ensure the search was repeatable: (inclusion) AND (strategies) AND (education or "middle school" or "high school") AND (classroom) NOT (administration) NOT ("higher education" or "teacher training") NOT (medicine). The exclusion of the last four items helped reduce the search results from 1623 to 503 articles.

I reviewed the abstracts and conclusions and skimmed the articles' content to select the most suitable papers according to the inclusion criteria. The resulting articles were narrowed further by excluding interventions or strategies that focused on primary aged students that I felt were not applicable to middle or high school science. For example, play based strategies that were used in primary outdoor education were excluded while self-assessment strategies used in elementary grades were included (Florian & Beaton, 2018). Other studies that were excluded were: those set in an alternative setting, those that required resources outside the classroom, those that included school-wide supports or interventions, those that focused on opinions of inclusion and those that focused on preservice teachers. Articles that gave an overview of a strategy without presenting research backing up the strategy were also excluded. Other articles that were excluded were those that relied on strategies taught and used specifically in the special education classroom. However, articles that included collaboration with special educators and strategies that were taught in small group settings but were then used in the general classroom were included.

These parameters resulted in 69 articles that were read in detail. Upon review, 24 of these articles were empirically based (presenting and analyzing empirical results), 10 were literature reviews, and 35 presented a framework for inclusion (while presenting the research base for the frameworks). The articles that focused on explaining frameworks were not included in the general content analysis. These were excluded because the content analysis analyzed strategies based mainly on prevalence rather than a detailed review of the strength of the supporting data within the studies. Including articles that rely on other literature to substantiate effectiveness of frameworks could over empathize a strategy and artificially inflate the prevalence of the strategy (as framework articles could all cite the same resources, magnifying its prevalence). The 10 literature reviews were included to insure sufficient breadth of strategies. Thirty-four articles remained after the framework articles were removed. The articles were analyzed in detail and coded for all applicable inclusive supports to provide a deeper understanding of supports available. The codes were then organized into themes and categories as they emerged.

Three themes emerged from the content analysis: 1- the focus, the benefit and the beneficiary of the strategy, 2 - the setting, the grade level and subject or activity, and 3 - the inclusive strategies (Table 2). The strategies theme was coded into seven categories: 1 - strategy instruction, 2 - peer assisted learning (PAL), 3 - collaboration with special education, 4 - differentiated instruction (DI), 5 - universal design for learning (UDL), 6 - behavior supports, and 7 - teacher practices. The teacher practices category had a large number and wide range of inclusive teaching strategies, so this category was split into five subcategories: 1 - teacher talk, 2 - involvement strategies, 3- cooperative learning, 4 - positive culture, and 5 - hands-on learning. The categories and subcategories were then coded and analyzed using descriptive statistics (Creswell, 2015). I used Microsoft Excel software to code and analyze the data based on prevalence, relevance to the research question, and practicality of use in a high school science class. The results were used in the associated resources which allowed them to be responsive to the content analysis.

Table 2

Content Analysis Results Summary

Citation	Focus and Result	Setting	Strategy	Type
(Alasim, 2018)	DHH students increased participation	Grade 3, 5 general	Cooperative learning, Positive culture, Teacher practices	Empirical
(Alquraini & Gut, 2012)	Students w/ severe disabilities (SD) increased academic, social, or communication skills	K-12 general	Peer assisted learning (PAL), Technology, Cooperative learning, Teacher practices, UDL, DI	Lit review
(Awada & Plana, 2018)	Students w/ learning disabilities (LD) increased reading comprehension	Middle school reading	Strategy Instruction, Teacher Practices (env. supports)	Empirical
(Berry, 2006)	Students w/ LD increased participation	Elementary writing	Teacher practices (teacher talk and involvement strategies)	Empirical
(Bradley, 2016)	Students w/ ASD and peer tutors saw social and learning benefits	High school	PAL	Empirical
(Capp, 2017)	All students improved in learning process	K-12 general	UDL	Lit review
(Carter et al., 2007)	Students w/ SD showed higher engagement	High school science and art	PAL	Empirical
(Casale-Giannola, 2012)	All students increased participation or learning outcomes (including students w/ SD)	High school math, science, English, SS, health and vocational	DI, Collaboration, Strategy Instruction, Teacher practices (culture/engagement/hands-on)	Empirical
(Cihak & Castle, 2011)	Students w/ LD increased writing outcomes	Grade 8 writing	Strategy Instruction	Empirical
(Clarke et al., 2016)	Students w/ intellectual disabilities increased participation and on task-behavior	Grade 3 science and SS	Teacher practices (engagement)	Empirical
(Doğanay-Bilgi & Özmen, 2014)	Students w/ severe intellectual disabilities increased text comprehension	Middle school reading	Strategy Instruction, Teacher practices (teacher talk)	Empirical
(Duchaine et al., 2018)	All students (LD, ASD and behaviour) increased engagement and learning outcomes and decreased behaviours	High school science and math	Teacher Practices (engagement)	Empirical
(Florian & Beaton, 2018)	All students increased participation and feelings of inclusion	Elementary	Teacher practices (engagement)	Empirical
(Hitchcock et al., 2016)	All students (culturally and linguistically diverse) all increased writing skills	Middle school science writing	Technology, UDL, Strategy Instruction	Empirical
(Hudson et al., 2013)	Students w/ SD disabilities increased learning outcomes	K-12 general	Strategy Instruction	Lit review
(Karhu et al., 2018)	Students w/ ADHD or severe behaviors increased engagement and time in class	Grade 2,6 and 9 general	Behaviour Supports	Empirical
(Kuntz & Carter, 2019)	Students w/ intellectual disabilities increased participation, communication, and learning outcomes	High School content areas	Strategy Instruction, PAL	Lit review
(Lourenco et al., 2015	Students w/ LD and severe disabilities increased learning outcomes	K-12 general	DI, Collaboration (advisory only), Techn ology	Lit review
(Mason et al., 2017)	All students increased writing outcomes (less for students w/ LD)	Grade 5 and 6 science	Strategy Instruction	Empirical
(Mastropieri et al., 2005)	Benefits found for all students (increased help, smaller groups, work at their level)	Grade 4/7 science, 8 SS, 10 history, high school chemistry	Collaboration	Empirical
(Mastropieri et al., 2006)	All students increased science learning outcomes	Middle school science	DI, Teacher Practices (Cooperative and Hands-on learning)	Empirical
(Mastropieri & Scruggs, 2001)	Students w/ LD increased learning outcomes and participation	High School science, math, SS, English	Strategy Instruction, Collaboration, PAL	Lit review
(McAllum, 2014)	Students w/ LD (or challenges) improved reading comprehension, metacognition, and self-management	K-12 reading in content areas	Strategy Instruction	Lit review

Citation	Focus and Result	Setting	Strategy	Type
(Montague et al., 2011)	All students (includes students w/ LD) increased math problem-solving strategy application and learning outcomes	Middle school math	Strategy Instruction	Empirical
(Morningstar et al., 2015)	All students increased participation, engagement and writing outcomes	Middle and elementary writing	DI, Collaboration, UDL, Positive Behavioral Supports, PAL, Technology	Empirical
(Mulcahy et al., 2014)	Students w/ challenging behaviour increased math understanding and decreased problem behaviours	Middle to high school math	Behaviour Supports, Strategy Instruction, PAL, Technology	Lit review
(Ohtake, 2003)	Students w/ SD increased participation and peers' acceptance increased	K-12 general	DI, PAL	Lit review
(Rappolt-Schlichtmann et al., 2013)	All students improved science learning outcomes including students w/ disabilities	Upper Elementary- grade 4-7	Technology, UDL	Empirical
(Schmidt et al., 2002)	All students increased learning outcomes in reading including those with disabilities	Elementary- K-7	Strategy Instruction	Lit review
(Sorensen & Andersen, 2017)	Students w/ attentional difficulties (includes ADHD, LD and ASD) increased participation and feelings of inclusion	Grade 4-10	Technology	Empirical
(Trussell et al., 2016)	Students w/ challenging behaviour showed decreased problem behaviour	Middle and Elementary	Teacher Practices (teacher talk), Behaviour Support	Empirical
(Wehmeyer et al., 2003)	Students w/SD increased self-regulation and goal attainment and decreased problem behaviours	High school	Strategy Instruction (small group)	Empirical
(Wood et al., 2015)	Students w/ SD increased participation and engagement	Elementary- grade 5 SS	Strategy Instruction (small group)	Empirical
(Zhang et al., 2015)	All students showed gains in math outcomes. Students w/ disabilities biggest gains.	Elementary- grade 4 math	Technology	Empirical

Data Analysis

During this review, the articles included were literature reviews as well as those that presented empirical data. This may cause certain inclusive strategies to be over or under emphasized as they were analyzed partially by prevalence. Literature reviews may have cited the same articles that were included in the empirical articles or contained articles outside the search parameters. Strategy instruction may have been over emphasized because the word 'strategy' was used as a keyword while searching for articles. Also, strategies that lent themselves well to empirical research may have been over emphasized. For example, strategy instruction involves applying a specific treatment thus lends itself well to empirical research and data collection.

The method of coding articles also contained objective elements. To decrease objective elements and increase rigor, well defined inclusion criteria was used for each category. However, many of the categories had some overlapping components. When this occurred, overlaps were highlighted, and subjective judgements were discussed. Finally, the articles included in this review varied between quantitative empirical studies and qualitative studies. Some studies were highly objective focusing on testing results and pre-post intervention data, while others focused on observational and qualitative measures, such as feelings of inclusion. This means that articles reviewed may have differing criteria for deeming a strategy effective. Differing criteria may have impacted the validity of the results as the strength of data backing up the strategies effectiveness was not examined in detail. Some articles reported studies as effective inclusive strategies if teachers and students feelings of inclusion increased, while other articles measured participation rates, or performance on academic skill assessments. These differing measures of effectiveness were not weighed against each other because aim of this content analysis was to give overview of inclusive strategies that would be effective to use in a middle school science classroom rather than deeming which strategy most effective.

Results

Content analysis in this study sought to explore inclusive strategies found in the literature that would be applicable to middle school science classrooms. This section of the project presents the main findings according to the research question and the emerging themes.

Focus Theme

The first theme was the focus of the articles. The focus describes the student population that the strategy targets as well as the benefit of the strategy. The studies focused on and gave results for a variety of different student populations: the whole class, students with learning disabilities, students with low incidence disabilities, students with behavioral or attentional challenges and students without disabilities or challenges (Table 3). Eleven of the 34 articles focused on inclusive general classes. These studies tended to have diverse populations of students, including students with disabilities, English language learners (ELL), and those with diverse backgrounds, but these did not give results or data for each individual population. Mason et al., (2017) and Zhang et al. (2015) are exceptions because they gave results for populations of students with learning disabilities as well as results for the rest of the class. Five studies focused on inclusion of students with learning disabilities (high incidence disabilities). These five studies contained class wide as well as targeted supports and only reported results for students with learning disabilities**.**

Table 3

Focus Results

Results Given for	Citations	Count
Inclusive classes	(Capp, 2017) (Casale-Giannola, 2012) (Duchaine et al., 2018) (Florian & Beaton, 2018) (Hitchcock et al., 2016) (Mastropieri et al., 2005) (Mastropieri et al., 2006) (Montague et al., 2011) (Morningstar et al., 2015) (Rappolt-Schlichtmann et al., 2013) (Schmidt et al., 2002)	11
Students w/ LD (high incidence)	(Awada & Plana, 2018) (Berry, 2006) (Cihak & Castle, 2011) (Mastropieri & Scruggs, 2001) (McAllum, 2014)	5
Students w/ LD and rest of the class (two groups)	(Mason et al., 2017) (Zhang et al., 2015)	2
Students w/ SD (low incidence)	(Alasim, 2018) (Alquraini & Gut, 2012) (Bradley, 2016) (Carter et al., 2007) (Clarke et al., 2016) (Doğanay Bilgi & Özmen, 2014) (Hudson et al., 2013) (Kuntz & Carter, 2019) (Lourenco et al., 2015) (Ohtake, 2003) (Wehmeyer et al., 2003) (Wood et al., 2015)	12
Students w/ behaviour challenges	(Karhu et al., 2018) (Mulcahy et al., 2014) (Sorensen & Andersen, 2017) (Trussell et al., 2016)	4

Twelve of the 34 articles focused on inclusion of students with low incidence or severe disabilities. Severe disabilities' includes students with severe to moderate cognitive impairments and students with low incidence disabilities such as students with Autism Spectrum disorder (ASD) or Deaf and Hard of Hearing (DHH) students. Four of the 12 studies contained class wide strategies (Alquraini & Gut, 2012; Clarke et al., 2016; Lourenco et al., 2015; Ohtake, 2003). However, in eight of the 12, some aspect of the strategy was taught solely to the focus students and the strategy was used in the general classroom Thus in these eight studies the purpose of the strategy was to facilitate inclusion in the general classroom. When reporting results, 11 of 12, reported positive results for the focus group of students but did not provide results for the other groups of students. The exception was Duchaine et al. (2018) which presented results for students with ASD and the small group of peer tutors who worked with them. Four articles focused on students with behavioral and attentional based challenges which included those with attention deficit hyperactivity disorder (ADHD). These studies all applied a strategy class wide as well as using specific supports for the focus students, and all studies found benefits for the focus students.

The range in focus of the articles was diverse containing a variety of exceptionalities and abilities. All articles reviewed showed benefits to students with exceptionalities and many showed benefits to the general student population. The range of focus of the articles indicates that the benefits of the inclusive strategies surveyed could be generalized to many diverse inclusive classrooms. This indicates that these strategies may be appropriate for middle school science.

Setting Theme

The next theme was the setting (Table 4). This included the grade level, subject, class or activity. All articles met the inclusion criteria of being applicable to middle school science (Table 2) so most of the studies were in similar settings to middle school science. Nineteen of the articles were set in middle and high school levels, eight included intermediate and upper elementary grades and seven were set across all grade levels. One study was set in the third grade (Clarke et al., 2016) it was still included even though the setting was below middle school because the subject area, science, and strategy, response cards, were deemed applicable to middle school science. The study used response cards which are a strategy for participation which is recommended for use in middle and high school science (Schwab et al., 2013)

Table 4

Setting Results

	General	Science	Math	English	Socials	Writing	Reading	Other
All Grades								
(Alquraini & Gut, 2012)	✓							
(Capp, 2017)	✓							
(Hudson et al., 2013)	✓							
(McAllum, 2014)	✓						✓	
(Ohtake, 2003)	✓							
(Sorensen & Andersen, 2017)	✓							
Middle and High School								
(Awada & Plana, 2018)							✓	
(Bradley, 2016)	✓							
(Carter, et al., 2007)		✓						Art
(Casale-Giannola, 2012)		✓	✓	✓	✓			Health
(Cihak & Castle, 2011)						✓		
(Doğanay et al., 2014)						✓		
(Duchaine et al., 2018)		✓	✓					
(Hitchcock et al., 2016)		✓						
(Karhu et al., 2018)	✓							
(Kuntz & Carter, 2019)	✓							
(Lourenco, et al., 2015)	✓							
(Mastropieri et al., 2005)		✓			✓			
(Mastropieri et al., 2006)		✓						
(Mastropieri & Scruggs, 2001)		✓	✓	✓	✓			
(Montague et al., 2011)			✓					
(Morningstar et al., 2015)						✓		
(Mulcahy et al., 2014)			✓					
(Trussell et al., 2016)	✓							
(Wehmeyer et al., 2003)	✓							
Intermediate								
(Alasim, 2018)	✓							
(Berry, 2006)						✓		
(Florian & Beaton, 2018)	✓							
(Mason et al., 2017)		✓						
(Rappolt-Schlichtmann et al., 2013)		✓						
(Schmidt et al., 2002)							✓	
(Wood et al., 2015)					✓			
(Zhang et al., 2015)			✓					
Elementary								
(Clarke et al., 2016)		✓			✓			

Fourteen of the studies were set in inclusive, general education classes and did not mention specific content areas. Four were set in science classes and six were set in multiple classes including science classes. Five were set in other content area classes such as math, English, and social studies. A few studies described their setting by the academic skill, such as writing (three studies) or reading (two studies). The setting of all articles included in the review were applicable to middle school science because they were at a similar level, similar content area or include skills that would be important in middle school science.

Strategies for Inclusion Theme

The next theme is strategies for inclusion (Table 5). Inclusive strategies were coded into eight different categories: teacher practices, strategy instruction, peer assisted learning (PAL), technology, universal design for learning (UDL), differentiated instruction (DI), collaboration, and behavior supports. The categories were discussed based on prevalence and relevance to use in middle school science classes.

It is important to note that most studies examined multicomponent interventions that included more than one strategy (Table 2). This means that articles were often coded with multiple strategies. The strategy count, 67, is higher than the number of articles, 34. For example, studies focused on collaboration with special education teachers also often incorporated DI (Casale-Giannola, 2012; Lourenco et al., 2015; Mastropieri et al., 2006; Morningstar et al., 2015). However, when the categories overlapped the article was coded for the most in depth strategy it qualified for. For instance, studies coded with complex strategies (e.g. UDL, DI, and strategy instruction) inherently contain teacher practices that overlap with less complex teacher practice category (Alquraini & Gut, 2012; Casale-Giannola, 2012; Doğanay Bilgi & Özmen, 2014; Kuntz & Carter, 2019; Mulcahy et al., 2014). I gauged complexity of the strategies based on her assessment of the amount of planning, resources, and training the teacher may need to learn and implement the strategy. For example, articles coded solely for strategy instructions

(Cihak & Castle 2011; Hudson et al., 2013; Mason et al., 2017; McAllum, 2014; Montague et al., 2011) contained teacher practices (involvement strategies and teacher talk). Since the strategy instruction was deemed more complex than the teacher practice, the article was only coded as strategy instruction. Conversely, the teacher practice subcategories may involve strategies that do not fully fit into the first main categories. For example, a study involving only teacher modeling would be coded as teacher practices, with the subcategory teacher talk, as it lacked the breadth of inclusion criteria for to be coded as a strategy instruction. The following section is a detailed examination of the strategies of inclusion.

Table 5

Strategies for Inclusion Results

Strategy	Citations	Count
Strategy Instruction	(Awada & Plana, 2018) (Casale-Giannola, 2012) (Cihak & Castle, 2011) (Doğanay Bilgi & Özmen, 2014) (Hitchcock et al., 2016) (Hudson et al., 2013) (Kuntz & Carter, 2019) (Mason et al., 2017) (Mastropieri & Scruggs, 2001) (McAllum, 2014) (Montague et al.,, 2011) (Mulcahy et al., 2014) (Schmidt et al., 2002) (Wehmeyer et al., 2003) (Wood et al., 2015)	15
Technology	(Alquraini & Gut, 2012) (Hitchcock et al., 2016) (Lourenco et al., 2015) (Morningstar et al., 2015) (Mulcahy et al., 2014) (Rappolt-Schlichtmann et al., 2013) (Sorensen & Andersen, 2017) (Zhang et al., 2015)	8
PAL	(Alquraini & Gut, 2012) (Bradley, 2016) (Carter et al., 2007) (Kuntz & Carter, 2019) (Mastropieri & Scruggs, 2001) (Morningstar et al., 2015) (Mulcahy et al., 2014) (Ohtake, 2003)	8
DI	(Alquraini & Gut, 2012) (Casale-Giannola, 2012) (Lourenco et al., 2015) (Mastropieri et al., 2006) (Morningstar et al., 2015) (Ohtake, 2003)	6
UDL	(Alquraini & Gut, 2012) (Capp, 2017) (Hitchcock et al., 2016) (Morningstar et al., 2015) (Rappolt-Schlichtmann et al., 2013)	5
Collaboration	(Casale-Giannola, 2012) (Lourenco et al., 2015 (Mastropieri & Scruggs, 2001) (Mastropieri et al., 2005) (Morningstar et al., 2015)	5
Behaviour supports	(Karhu et al., 2018) (Morningstar et al., 2015) (Mulcahy et al., 2014) (Trussell et al., 2016)	4
Teacher Practices:		
Teacher talk	(Alasim, 2018) (Alquraini & Gut, 2012) (Berry, 2006) (Doğanay Bilgi & Özmen, 2014) (Trussell et al., 2016)	5
Involvement Strategies	(Berry, 2006) (Casale-Giannola, 2012) (Clarke et al., 2016) (Duchaine et al., 2018) (Florian & Beaton, 2018)	5
Cooperative Learning	(Alasim, 2018) (Alquraini & Gut, 2012) (Mastropieri et al., 2006)	2
Positive Culture	(Alasim, 2018) (Casale-Giannola, 2012)	2
Hands-on Learning	(Casale-Giannola, 2012) (Mastropieri et al., 2006)	2

Strategy Instruction Results. Strategy instruction was coded in 15 of the 34 articles (Table 6). Inclusive criteria for a strategy instruction was the teacher teaching, usually by direct, explicit instruction, a strategy that students then used to increase learning or change behaviors.

This included strategies for reading comprehension, problem solving, writing, and self-regulation. Although the strategy instruction used varied between studies, all found strategy instruction to be beneficial. Some strategy instructions were found to be effective for all students (Casale-Giannola, 2012; Cihak & Castle, 2011; Hitchcock et al., 2016; Mason et al., 2017; Montague et al., 2011; Schmidt et al., 2002). One found strategy instruction to be beneficial for students with challenging behaviors (Mulcahy et al., 2014). Three found strategy instruction beneficial for students with learning disabilities (Awada & Plana, 2018; Mastropieri & Scruggs, 2001; McAllum, 2014). Five found strategy instruction to be beneficial for students with low incidence disabilities ((Doğanay Bilgi & Özmen, 2014; Hudson et al., 2013; Kuntz & Carter, 2019; Wehmeyer et al., 2003; Wood et al., 2015). Eleven of the 15 articles were set in middle or high school classes with three specifically set in science classes. Five other studies were set in K-12 classes.

Table 6

Strategy Instruction Results

Citation	Strategy Instruction	Focus	Setting
(Awada & Plana, 2018)	Class wide class reading comprehension strategy	Students w/ LD in reading increased reading comprehension	Middle school
(Casale-Giannola, 2012)	Class wide strategy instruction in behaviour management or skills as well as small group strategy instruction for basic skills.	Qualitative data shows increased inclusion (increased participation and/or learning outcomes)	High school math, science, English, SS, health and vocational
(Cihak & Castle, 2011)	Class wide explicit strategy instruction in writing	All students improved writing outcomes	Middle school
(Doğanay Bilgi & Özmen, 2014)	Students w/ SD were taught reading comprehension strategy in small group setting	Students w/ SD were able to apply the strategy in class and increase in text comprehension	Middle school
(Hitchcock et al., 2016)	Class wide strategy instruction in science writing (with technology and UDL)	All students showed gains in writing outcomes (included students w/LD)	Middle school science
(Hudson et al., 2013)	Engagement strategies for students w/ SD (embedded instruction in general classes)	Students w/ SD increased participation and learning	K-12
(Kuntz & Carter, 2019)	Students w/ intellectual disabilities were taught strategies for communication, self-regulation or academic skills	Students w/ intellectual disabilities showed increased self-regulation, learning or participation (depending on strategy taught)	High school
(Mastropieri & Scruggs, 2001)	Class wide strategy instruction (varied with article reviewed)	Many students w/ disabilities showed increased learning outcomes (not found in all cases)	High school science, math, SS and English
(Mason et al., 2017)	Class wide strategy instruction in persuasive writing	All students increased writing outcomes (students w/ LD saw less gains)	Elementary (grade 5/6)

Citation	Strategy Instruction	Focus	Setting
(McAllum, 2014)	Small group instruction on reciprocal teaching to increase reading comprehension and metacognitive skills	Students w/ LD and struggling readers improved in reading comprehension, metacognition, social anticipation, and self-management.	All levels
(Montague et al., 2011)	Class wide cognitive strategy instruction in math problem solving	All showed gains in math problem solving with students w/ LD showing higher gains	Middle school math
(Mulcahy et al., 2014)	Class wide strategy instruction for conceptual math skills	Students w/ behaviour increased math outcomes and decreased behaviour (higher when combined with behaviour supports)	Middle and high school
(Schmidt et al., 2002)	Class wide strategy instruction for reading non-fiction texts	All students improved science content learning outcomes	Elementary (K-7)
(Wehmeyer et al., 2003)	Self-regulation strategies taught to students w/ severe disabilities in small group setting	Students w/ SD were able to use strategies in general classes. Problem behaviours decreased and learning outcomes increased	High school
(Wood et al., 2015)	Students w/ intellectual disabilities were taught a reading comprehension strategy in small group setting	Students w/ intellectual disabilities were able to use the strategies in class and increased participation and engagement	Elementary (grade 5) social studies

All studies reported one or more benefit of strategy instruction depending on the strategy used. Strategy instruction was linked with increased learning outcomes in all studies, increased participation in four studies, and decreased challenging behaviors in three studies. Results from this review align with others, such as Donker et al. (2014), which found strategy instruction to be effective for increasing outcomes in writing, science, mathematics, and reading for students with various levels of ability. The articles reviewed suggest that strategy instruction has the potential to be a good inclusive strategy for middle school science as it can increase outcomes for all students including those with disabilities.

Strategy Instruction Discussion. Strategy instruction is often underutilized or poorly implemented in upper level science. As little as 3% of instructional time is spent coaching middle and high school students on strategies essential to understanding (Ness, 2007). To properly implement a strategy instruction, it must be employed with adequate intensity and duration (Cihak & Castle, 2011; Mason et al., 2017; Mastropieri & Scruggs, 2001). This may be challenging for some teachers in fast paced, higher level subjects (Mastropieri & Scruggs, 2001). Mastropieri and Scruggs (2001) found varying positive results of strategy instruction in high school content area classes. They suggest that the variations could be due to insufficient duration and intensity of strategy instruction for the complexity of material. Awada and Plana (2018) recommend that strategy instruction is carefully implemented for a long duration to ensure effectiveness. Simply overviewing a strategy in a fast-paced science class will likely not be effective (Mastropieri & Scruggs, 2001). In high school classes there is often a push to cover content rapidly and teachers can feel like they do not have time to sufficiently implement strategy instruction (Mastropieri & Scruggs, 2001). Adding strategy instruction may not be beneficial without commitment by teachers to ensure the strategy is taught for long enough that the students are comfortable and proficient using it.

Implementing strategy instruction may also involve collaboration with a special educator especially when targeting students with severe disabilities. In the studies reviewed, teachers were often able to implement strategies that showed benefits for all students, including those with high incidence disabilities such as learning disabilities and behavioral challenges (Awada & Plana, 2018; Cihak & Castle, 2011; Hitchcock et al., 2016; Mason et al., 2017; Montague et al., 2011). The teacher implemented the strategy instruction class wide and saw benefits for all students. However, implementing strategy instruction for students with more severe disabilities may take more planning and resources. In studies of inclusion of students with severe disabilities, the general classroom teacher often worked in conjunction with a special educator to implement the strategy usually in a small group setting (Doğanay Bilgi & Özmen, 2014; Kuntz & Carter, 2019; Wehmeyer et al., 2003; Wood et al., 2015). Thus, to use some strategies effectively the general teacher may find it beneficial to collaborate with special educators.

When implementing strategy instruction, it is important to help students increase their self-awareness and self-management of the strategy which could help them better use the strategy (Wehmeyer et al., 2003). Many of the strategy instructions reviewed included self-management and metacognitive aspects (Doğanay Bilgi & Özmen, 2014; Hitchcock et al., 2016; Kuntz & Carter, 2019; Mason et al., 2017; McAllum, 2014; Wehmeyer et al., 2003). Self-management and metacognition seemed to be an important aspect of a quality strategy instruction. A link has been found between instructing metacognitive knowledge and effectiveness of the strategy (Donker et al., 2014). Students who do not have any metacognitive knowledge about strategies cannot use appropriate comprehension strategies or manage the comprehension process (Doğanay Bilgi & Özmen, 2014). Thus, to increase the effectiveness of strategy instruction it may be important for teachers to teach metacognitive skills and self-management skills associated with it.

Results suggest that strategy instruction could be an effective inclusive strategy for middle school science classes. Science involves learning subject specific knowledge and skills (e.g. writing, reading, and science processes). This could make strategy instruction an appealing inclusive strategy as it can help all students to increase learning performance. Research reviewed indicated there are numerous beneficial strategy instructions rather than one single best strategy instruction. According to Awada and Plana (2018), different teachers reported different positive aspects and drawbacks of each strategy instruction for reading comprehension. In general, the strategy instruction should be carefully chosen by the teacher (Awada & Plana, 2018). The teacher should choose a strategy instruction that fits with the content area, skill, students' abilities, and teachers' teaching style and pedagogy (Awada & Plana, 2018). Teachers should ensure adequate intensity and duration of the strategy instruction, choose a strategy instruction that includes metacognitive and self-management aspects, and they may want to collaborate with a special educator. To be implemented properly strategy instruction may involve training, planning, and commitment but reviewed studies suggest it can be an effective inclusive strategy for middle school science.

Technology Results. Technology was coded as a strategy in eight of the articles reviewed (Table 7). The technology category included a range of technological supports used by students or teachers. Inclusive criteria for technology was being a technological support used in the general classroom by the teacher or student to increase inclusion. Supports coded in the technology category were assistive technology for specific student needs (Alquraini & Gut, 2012; Lourenco et al., 2015); technology for students to practice skills (Mulcahy et al., 2014; Zhang et al., 2015); technology to assist students showing their learning (Hitchcock et al., 2016; Mulcahy et al., 2014; Sorensen & Andersen, 2017); and technology used by the teacher to assist teaching (Morningstar et al., 2015; Mulcahy et al., 2014). The studies were set in grades K-12 with one set in elementary science (Rappolt-Schlichtmann et al., 2013), and one in middle school science (Hitchcock et al., 2016). Five of the eight studies found that technology increased learning outcomes in all students including students with disabilities (Hitchcock et al., 2016; Lourenco et al., 2015; Mulcahy et al., 2014; Rappolt-Schlichtmann et al., 2013; Zhang et al., 2015) while the other three studies only reported gains for target groups of students with disabilities (Alquraini & Gut, 2012; Lourenco et al., 2015; Sorensen & Anderson, 2017). Technology was also associated with increased access and inclusion for students with disabilities (Morningstar et al., 2015), students with severe disabilities (Alquraini & Gut, 2012) and students with attentional challenges (Sorensen & Andersen, 2017).

Table 7

Technology Results

Citation	Technology	Focus	Setting
(Alquraini & Gut, 2012)	Assistive technology (ability specific)	Increased access for students w/ SD.	K-12
(Hitchcock et al., 2016)	Multimedia technology combined with UDL and strategy instruction to increase writing.	Improved writing for all students (including general and special education students)	Middle school science writing
(Lourenco et al., 2015)	Assistive technology (visual, communication or other ability specific)	Increased knowledge, skills, and autonomy in students with disabilities especially when combined with DI and teaching practices.	K-12
(Morningstar et al., 2015)	Learning technology used by teachers	Technology used by teachers can increase access and participation for all students.	Middle and elementary
(Mulcahy et al., 2014)	Anchored instruction (video based) and computer/iPad assisted instruction	Increased math learning outcomes for all students	Middle and high school math
(Rappolt-Schlichtmann et al., 2013)	Web-based science notebooks (with UDL)	Both students with and without disabilities showed improved science content learning outcomes compared to pen/paper.	Elementary science
(Sorensen & Andersen, 2017)	Digital technology to assist with process of production	Increased learning outcomes for students with attentional difficulties.	Grades 4-10
(Zhang et al., 2015)	Math apps targeting conceptual math skills (self-paced)	All students showed increased learning outcomes. Students with LD showed more gains.	Elementary (grade 4)

Technology Discussion. Lourenco et al. (2015) warn that just having technology available does not guarantee it will benefit learning. The teacher and students must use the technology frequently and well. Rappolt-Schlichtmann et al. (2013) saw the biggest positive gains from technology in classes where teachers had more experience and training with the technology. To increase the benefits from technology, it must also be combined with good teaching practices (Lourenco et al., 2015).

In some of the studies reviewed, technology was intertwined with other inclusive strategies such as universal design for learning (UDL) and differentiated instruction (DI) (Hitchcock et al., 2016; Lourenco et al., 2015; Rappolt-Schlichtmann et al., 2013; Zhang et al.,2015). Technology use can allow for differentiation and help to provide the principles of UDL (Table 1). The web-based science notebooks used by Rappolt-Schlichtmann et al. (2013) and the multimedia technologies used in Hitchcock et al. (2016) were intentionally combined with the

UDL framework. When differentiating learning, technology can help provide adaptations and modifications for individual students. Lourenco et al. (2015) specifically used technology with DI, and the math apps used in Zhang et al. (2015) provide automatic differentiation of learning tasks to fit each student's level. The studies reviewed indicate that technology could be a good inclusive strategy for a middle school science if teachers are comfortable with the technology, use it often, and possibly link it with other strategies.

Peer Assisted Learning (PAL) Results. PAL was coded in eight of the studies (Table 8). Inclusion criteria for strategy instruction included peer tutoring and peer support scenarios where peers assisted peers. PAL increased engagement and participation (Carter et al., 2007; Kuntz & Carter, 2019; Morningstar et al., 2015), social outcomes (Alquraini & Gut, 2012; Bradley, 2016; Morningstar et al., 2015; Ohtake, 2003), communication (Alquraini & Gut, 2012; Kuntz & Carter, 2019), learning outcomes (Mastropieri & Scruggs, 2001; Mulcahy et al., 2014), and decreased problem behaviors (Mulcahy et al., 2014). These results were found in elementary through to high school settings, with two studies specifically including in high school science (Carter et al., 2007; Mastropieri & Scruggs, 2001). The PAL studies showed benefits for students with severe disabilities (Alquraini & Gut, 2012; Carter et al., 2007; Ohtake, 2003), intellectual disabilities (Kuntz & Carter, 2019), ASD (Bradley, 2016), learning disabilities (Mastropieri & Scruggs, 2001), challenging behaviour (Mulcahy et al., 2014), and inclusive classes that included students with disabilities (Morningstar et al., 2015).

Table 8

Peer Assisted Learning (PAL) Results

Citations	Focus	Setting
(Alquraini & Gut, 2012)	Students w/SD increased communication and social outcomes. Increased essential components of inclusion.	K-12
(Bradley, 2016)	Students w/ASD showed gains in self-esteem, social satisfaction and decrease in feelings of bullying. Peer tutors showed gains in self-esteem.	High school
(Carter et al., 2007)	Students w/SD had higher engagement than with paraprofessional help.	High school science and art
(Kuntz & Carter, 2019)	Students w/ intellectual disabilities increased communication and participation.	High school
(Mastropieri & Scruggs, 2001)	Students w/LD showed increased learning outcomes in most reviewed studies (all studies found PAL more effective than independent study).	High school science, math, SS and English
(Morningstar et al., 2015)	All students including students w/ LD increased participation and engagement (more positive results in PAL vs cooperative learning or paraprofessional support).	Elementary and middle school
(Mulcahy et al., 2014)	Students w/ behaviour challenges increased math understanding and decreased problem behaviours.	Middle and high school math
(Ohtake, 2003)	Increased social inclusion for students w/SD. More positive results when students w/ disabilities contributed to others learning versus solely acting as the 'tutored' student.	K-12

Peer Assisted Learning (PAL) Discussion. Results suggest that PAL is an appropriate inclusive strategy for middle school science classes. It was found to be more effective than independent study (Mastropieri & Scruggs, 2001), cooperative learning (Morningstar et al., 2015; Ohtake, 2003), or paraprofessional support (Carter et al., 2007; Morningstar et al., 2015). Many of the studies recommend ensuring beneficial peer support scenarios. It is important to ensure a positive classroom and social environment (Mastropieri & Scruggs, 2001), and peer tutors must be carefully selected, trained, and monitored (Carter et al., 2007; Bradley, 2016). PAL was associated with positive outcomes in all the studies reviewed however if not done mindfully it can create divides in a classroom (Ohtake, 2003). When students without a disability tutor a student with a disability it can result in a parenting type relationship that does not typically result in full, inclusive class membership for the student with the disability (Ohtake, 2003). Students with disabilities should have opportunities to contribute to classmates learning and not always be in the role of the tutored student (Ohtake, 2003). Teachers must be mindful of social factors and ensure that everyone, especially those with exceptionalities, are valued and make real contributions to the class. Results suggest that PAL is a strategy that could be effective for middle school science classes. Teachers may have to choose, train, and monitor tutors to implement PAL. Teachers also may have to ensure all students have times when they contribute to learning and to ensure a positive classroom social environment.

Differentiated Instruction (DI) Results. DI was identified in six studies (Table 9). Inclusion criteria for DI included using methods of adapting or modifying curriculum and supports to help students of differing abilities. The adaptions and modifications had to be highlighted and they had to be a main benefit of the strategy. DI was found to be effective for a range of grades and student populations.

Table 9

DI Results

Citations	DI Explanation	Focus	Setting
(Alquraini & Gut, 2012)	Adaptations and modifications	Increased essential components of inclusion and increased access to curriculum for students w/SD.	K-12
(Casale-Giannola, 2012)	Adaptations and modifications	Increased participation and/or learning outcomes.	High school math, science, SS, English, health, and vocational
(Lourenco et al., 2015)	Differentiated instruction linked with assistive technology	Can increase effectiveness of assistive technology and increase inclusion of students w/LD and SD.	K-12
(Mastropieri et al., 2006)	Multi-component differentiated instruction	Students, including those with LD, increased learning outcomes in science.	Middle school science
(Morningstar et al., 2015)	Adaptations and modifications	Supported learning and increased access for students who received them.	Middle and elementary
(Ohtake, 2003)	Multilevel curriculum with multiple entry points and modifications	Increased inclusion and access for students w/SD. Stronger when contributing to others learning.	K-12

The studies ranged in setting with two studies including middle and high school science (Casale-Giannola, 2012; Mastropieri et al., 2006). DI increased inclusion and access for students with severe disabilities (Alquraini & Gut, 2012; Lourenco et al., 2015; Ohtake, 2003). In inclusive classrooms, including students with disabilities, DI increased inclusion, access (Morningstar et al., 2015), participation (Casale-Giannola, 2012), and learning outcomes (Casale-Giannola, 2012; Mastropieri et al., 2006; Morningstar et al., 2015).

Differentiated Instruction (DI) Discussion. Positive results from this review agreed with those found in other studies, such as Roy et al. (2013), where DI promoted inclusion in the general classroom. However, DI has the potential to cause exclusion (Ohtake, 2003). The teacher must not differentiate learning to the extent that students with challenges are routinely excluded from the learning activities of the rest of the class. The teacher can increase inclusion when using DI by ensuring that they are offering students with disabilities more than parallel activities with only thematic connections to the learning of the rest of the class (Ohtake, 2003). Offering only parallel activities to students with disabilities is more likely to happen for students who may need substantial modifications to the curriculum (Ohtake, 2003). Ohtake (2003) found that inclusion is better facilitated when students with disabilities contribute to others learning rather than just completing thematically similar activities. This means that teachers should employ DI so that all students are participating in similar ways and all students are using a range of supports.

DI is often combined with other strategies especially technology and collaboration with special educators. Three studies (Alquraini & Gut, 2012; Lourenco et al., 2015; Morningstar et al., 2015) use both DI and technology supports. In Lourenco et al. (2015), they noted the ability of the technology to provide DI as one of its strengths. Lourenco et al. (2015) was coded for both DI and technology because it met the inclusion criteria for DI by pairing technology use with adaptations and modifications beyond that of the technology alone. In Alquraini and Gut (2012) and Morningstar et al. (2015) assistive technology that assisted with reading and writing helped provide DI for students with disabilities. DI was also used in conjunction with collaboration with special educators as the special educator was in class specifically to help provide many of components of DI (Casale-Giannola, 2012; Lourenco et al., 2015; Mastropieri et al., 2005; Morningstar et al., 2015).

The prevalence of DI may be somewhat under-represented in this content analysis. There was some overlap between DI and other strategies, such as technology and collaboration, but if studies failed to meet the inclusion criteria for DI they were not included in the category. Adaptions and modifications had to be a main, highlighted benefit of the strategy, to meet the inclusion criteria for DI. In Zhang et al. (2015), differentiation was built into the math technology used, as it allowed for self-pacing and focus on individual needs. Similarly, in some of the cases presented in Mastropieri and Scruggs (2001), the roles of the collaborating special educators included helping to adapt handouts and strategies. However, in both studies, these adaptions and modifications were implied and there was not enough information given to meet the inclusion criteria for DI.

The number of adaptations and modifications that may be necessary for effective DI may be one of its largest drawbacks. High school science teachers often report that they would discontinue DI if they did not have access to a special education co-teacher (Mastropieri & Scruggs, 2001). The resource of a special education co-teacher may not be available to many teachers and the planning and execution of DI may take significant effort and changes in pedagogy for some teachers. Other strategies, such as technology or teacher practices, may have similar benefits with less teacher effort. According to Morningstar et al. (2015), when creating lessons and class materials less specialized adaptations are needed with strategies such as UDL. Results suggest that DI can be an effective inclusive strategy for middle school science classes; however, teachers must consider their resources and class needs when deciding to implement DI.

Universal Design for Learning (UDL) Results. UDL was coded in five studies (Table 10). Inclusion criteria for UDL involved the use of the UDL framework (Table 1). The UDL framework is defined by following three key principles of providing multiple means of:

engagement, representation, and expression (Meyer et al., 2016). The studies reviewed were a meta analysis investigating the effectiveness of UDL (Capp, 2017), a literature review of inclusive strategies for students with severe disabilities (Alquraini & Gut, 2012), an investigation of inclusive strategies used at multiple schools (Morningstar et al., 2015), a study combining UDL with technology and a writing strategy instruction (Hitchcock et al., 2016), and a study combining UDL with technology use (Rappolt-Schlichtmann et al., 2013). The setting of the articles spanned grades K-12, with one being set in elementary science (Rappolt-Schlichtmann et al., 2013), and one in middle school science (Hitchcock et al., 2016). UDL was shown to be effective for increasing learning outcomes for all students including students with disabilities (Hitchcock et al., 2016; Rappolt-Schlichtmann et al., 2013), for increasing inclusion and access for all students including students with disabilities (Capp, 2017; Hitchcock et al., 2016; Morningstar et al., 2015; Rappolt-Schlichtmann et al., 2013), and for increasing inclusion for students with severe disabilities (Alquraini & Gut, 2012).

Table 10

UDL Results

Citations	UDL	Focus	Setting
(Alquraini & Gut, 2012)	Framework	Increased essential components of inclusion and increased access to curriculum for students w/SD.	K- 12
(Capp, 2017)	Framework	Meta-analysis suggests UDL is effective for increasing access and improving the learning process for all students.	All levels
(Hitchcock et al., 2016)	Framework (w/tech and writing intervention)	Improved writing for all students (general and special education).	Middle school science writing
(Morningstar et al., 2015)	Framework	All students increased participation and access.	Middle and elementary
(Rappolt-Schlichtmann et al., 2013)	Framework (w/ tech)	Both students w/ and w/out disabilities increased science outcomes compared to pen/paper.	Elementary science

Universal Design for Learning (UDL) Discussion. The studies reviewed agree with Al-Azawei et al., (2016), that found UDL helped increase inclusion and learning for a diverse range of students. However, Capp (2017) warns that the benefit of UDL on learning has not been fully supported by research. Capp (2017) agrees that research has associated UDL with learning gains, however, he warns that learning benefits have yet to be adequately demonstrated through experimental studies in curriculum areas. This contention may be due to the complexity of UDL and various ways in which it is implemented. Implementing UDL could look very different for different teachers which could impact the results.

UDL is a multicomponent strategy that can include a broad range of approaches for providing multiple means of expression, representation, and engagement (Meyer, et al., 2016). This means that UDL can be very flexible and fit with teachers' pedagogy and teaching style, but it also means that it may involve increased planning and resources to fully implement. UDL is an effective tool to support learning for all students, including students with severe disabilities (Alqurainі & Gut, 2012). However, less complicated strategies, such as response prompting and embedded instruction, have also shown to be effective inclusive strategies (Alquaraini & Gut, 2012). Morningstar et al. (2015) found that UDL requires less specialized adaptations than DI and observed that students with disabilities were less likely to use specialized supports when universal supports were available in class. This may be important in middle school science because specialized supports may negatively impact students' social inclusion. As a middle school teacher, I have found that many students choose not to use supports that would make them feel or look different from their peers.

As was mentioned above, UDL is a complex strategy. Teachers, especially those looking to include small changes to their teaching, need to reflect on UDL to see if it would be a sustainable practice for them. However, a teacher could start implementing one principle of UDL at a time, slowly incorporating more as they build their experience and knowledge. Results indicated that UDL can be an effective inclusive strategy for middle school science. It is appealing because of its flexibility and potential to help teachers develop their own inclusive teaching practices over time.

Collaboration Results. Collaboration was coded in five studies (Table 11). Inclusion criteria for collaboration included teachers from the same school teaching, planning, and/or consulting together. It included co-teaching, collaboration, and consultation with special educators in all studies except for Lourenco et al. (2015), which only involved consultations. One study was a literature review containing studies in K-12 settings (Lourenco et al., 2015), the rest were set in middle or high schools, with three of them situated in science classes (Casale-Giannola, 2012; Mastropieri et al., 2005; Mastropieri & Scruggs, 2001). In general, the studies found that collaboration with special education teachers increased student participation (Casale-Giannola, 2012; Morningstar et al., 2015), led to increased learning outcomes for students with disabilities (Casale-Giannola, 2012; Lourenco et al., 2015; Mastropieri et al., 2005; Mastropieri & Scruggs, 2001), and resulted in more frequent and more successful student supports provided by teachers (Lourenco et al., 2015; Morningstar et al., 2015).

Table 11

Collaboration Results

Citations	Collaboration Type	Focus	Setting
(Casale-Giannola, 2012)	Consultation and co-teaching	Increased inclusion, increased participation and/or learning outcomes.	High school math, science, English, SS, health, and vocational settings
(Lourenco et al., 2015)	Consultation only	Increased effectiveness of assistive technology, increased learning, social and communication outcomes for students w/ LD and SD.	K-12
(Mastropieri & Scruggs, 2001)	Consultation and co-teaching	Students w/LD increased academic outcomes (not found in all cases).	High school science, math, SS and English
(Mastropieri et al., 2005)	Consultation and co-teaching	Increased achievement, attendance, social and attitudinal outcomes for students with disabilities (benefits varied between teaching teams).	Grade 4, 7 science, 8 SS, 10 history, high school chemistry
(Morningstar et al., 2015)	Consultation and co-teaching	All students showed increased participation. Increased frequency and more success of student supports.	Middle and elementary school

Collaboration Discussion. The studies in this review generally found collaboration to be an effective inclusive strategy. Consultations with special education teachers can help teachers understand students' abilities and needs, particularly with students with exceptionalities. Co-teaching also has many benefits for all students as it can allow for DI and small group learning. Science classes are predominantly lecture based (McKinney & Frazier, 2008) and if done well, collaboration could help science teachers decrease the amount of lecture style instruction and help facilitate inclusion of all students (Casale-Giannola, 2012).

Although collaboration with special education teachers was generally beneficial, the biggest variations were seen in the studies surrounded co-teaching. Some collaborative teams studied did not see any benefits (Mastropieri et al., 2005; Mastropieri & Scruggs, 2001) and some found variations in benefits of co-teaching between teams (Casale-Giannola, 2012; Morningstar et al., 2015). Having another teacher present in the classroom did not always translate to large benefits to students (Mastropieri et al., 2005; Mastropieri & Scruggs, 2001). Co-teaching is complex and can be challenging to do well. The most effective collaboration teams had compatible teaching styles where both teachers practiced effective behaviors (Casale-Giannola, 2012; Mastropieri, 2005).

Other factors that led to effective co-teaching were having time for co-planning, using disability-specific teaching adaptations, having expertise in the content area (Mastropieri et al., 2005), having effective instructional skills, and having effective classroom management (Mastropieri et al., 2005; Mastropieri & Scruggs, 2001). Casale-Giannola (2012) warns that for co-teaching to work teachers need to learn how to effectively co-teach. There are many co-teaching models available and teachers need to select one that fits with their teaching styles and team strengths. Typically, teachers lack training in co-teaching and time for co-planning

(Magiera & Zigmond, 2005). Without proper training or common planning time, teachers can end up teaching as they would alone, which reduces the benefits of co-teaching (Magiera & Zigmond, 2005).

Results suggest that collaboration with special educators may be an effective inclusive strategy for middle school science. Teachers who collaborate with special education teachers would likely benefit from consultation about their students with disabilities, exceptionalities, or challenges. However, co-teaching can be resource heavy as it relies on access to a second teacher, training, and time for planning.

Behaviour Supports Results. Behaviour supports were coded in four of the articles (Table 12). This category encompassed interventions or supports focused on changing student behaviour. This included positive behaviour supports (Karhu et al., 2018; Trussell et al., 2016) and behaviour interventions combined with other strategies (Morningstar et al., 2015; Mulcahy et al., 2014). All of the studies in this category included class-wide behavioral supports as well as targeted supports done solely with students with problem behavior. Targeted supports were unique and designed for a specific student. Class-wide supports included clear, consistent behaviour expectations (Karhu et al., 2018; Morningstar et al., 2015) and teacher talk strategies (Trussell et al., 2016). All studies reviewed had settings that included middle school, and all found that rates of challenging behaviour decreased with the use of behaviour supports.

Table 12

Behaviour Supports Results

Citation	Support	Focus	Setting
(Karhu et al., 2018)	Positive behaviour support. Class wide expectations and targeted supports.	Decreased problem behaviour and increased participation, learning and communication.	Grades 2, 6 and 9
(Morningstar et al., 2015)	Class wide behavioral expectations, interventions, supports, and targeted supports.	Reduced problem behaviour.	Middle/ elementary
(Trussell et al., 2016)	Positive behaviour support includes class wide teacher talk strategies and targeted supports.	Decrease in problem behaviour for all students, stronger with teaching strategies.	Middle/ elementary
(Mulcahy et al., 2014)	Class wide and targeted behaviour interventions and strategies.	Increased productivity and math outcomes and decreased problem behaviours.	Middle/ high school math

Behaviour Supports Discussion. The studies reviewed indicate that behavioral strategies could be beneficial for increasing inclusion and reducing problem behaviours in middle school science. Middle school science teachers could use class wide behaviour supports and add targeted supports for individual learners as needed. Science is often taught through whole class direct instruction (McKinney & Frazier, 2008) which can be more effective when teachers use empirically supported behaviour management strategies (Morningstar et al., 2015). Challenging behaviour often interferes with student learning (Karhu et al., 2018; Trussell et al., 2016) and addressing these behaviours can increase learning (Mulcahy et al., 2014).

It may be beneficial for middle school science teachers to use class wide behaviour strategies in conjunction with academic strategies to increase learning. Mulcahy et al. (2014) found that behavioral and academic strategies can be combined to address academic performance as well as behaviour for students with behavioural challenges in middle and high school. These findings are similar to Wehmeyer et al. (2003) and Casale-Giannola (2012) who found that strategy instructions that included behaviour management components helped increase learning outcomes and participation while decreasing problem behaviours. Results from this review suggest that behaviour supports could be an effective inclusive strategy to include in middle school science class.

Teacher Practices Results. The teacher practices category was coded 17 times and was the most prevalent and diverse category (Table 13). Inclusive criteria involved being a strategy for inclusion done solely by the classroom teacher for use in their class. The teacher practices category was split into five subcategories: teacher talk, involvement strategies, cooperative learning, positive culture, and hands-on learning. Teacher talk included strategies a teacher used while speaking or during direct instruction. Involvement strategies included strategies to increase student engagement. Cooperative learning included students working together on a learning task, where the intent was collaboration rather than peer to peer instruction. Positive culture included the teacher trying to increase the positive culture of the class. Hands-on learning included learning activities that involved manipulatives or hands-on activities. The teacher practices category was large because it included strategies that did not fully fit into the earlier categories and it included less resource intensive strategies compared to other categories. The teacher practices category contained strategies that required less training, and involved less planning time than other categories, such as universal design for learning (UDL) and differentiated instruction (DI).

Table 13

Teacher Practices Results

Practice	Citation	Description	Focus and Result	Setting
Teacher Talk	(Alasim, 2018)	Speaking rate, wait time and directed questions.	Increased participation of DHH students.	Grade 3 and 5
	(Alquraini & Gut, 2012)	Response prompting and cues.	Increased academic and communication outcomes and participation for students w/SD.	K-12
	(Berry, 2006)	Modeling and procedural strategies.	Increased verbal participation of all students including those w/LD.	Elementary
	(Doğanay Bilgi & Özmen, 2014)	Think alouds and interactive dialogues.	Students w/SD increased text comprehension.	Middle school
	(Trussell et al., 2016)	Instructional talk, modeling, wait time, prompts, and positive feedback.	Rates of problem behaviour decreased.	Middle and elementary
Involvement Strategies	(Berry, 2006)	Encouraging, orchestrating, sharing ownership and scaffolding.	Increased verbal participation of all students including those w/LD.	Elementary
	(Casale-Giannola, 2012)	Real life and career connections.	Increased participation and/or learning outcomes.	High school math, science, English, SS, health, and vocational
	(Clarke et al., 2016)	Response cards.	Increased participation and on-task behaviour of students w/ SD when compared to hand raising.	Elementary science and SS
	(Duchaine et al., 2018)	Response cards.	Increased participation, engagement and learning outcomes, decreased problem behaviours in all students (included LD, ASD and challenging behaviours).	High school science and math
	(Florian & Beaton, 2018)	Student self-assessments.	Teachers and students reported higher feelings of inclusion.	Elementary
Cooperative Learning	(Alasim, 2018)	Small group learning activities.	Increased participation and interaction of DHH students.	Grade 3 and 5
	(Alquraini & Gut, 2012)	Cooperative learning groups.	Increased academic, social and communication outcomes for students w/SD.	K-12
	(Mastropieri et al., 2006)	Collaborative hands-on activities.	Facilitate learning of science content (includes students w/LD).	Middle school science
Positive Culture	(Alasim, 2018)	Training other students in sign language and awareness.	Increased participation and interaction of DHH students.	Grade 3 and 5
	(Casale-Giannola, 2012)	Community building.	Facilitated inclusion (increased participation and/or learning outcomes).	High school math, science, English, SS,

Practice	Citation	Description	Focus and Result	Setting
				health, and vocational settings
Hands-on Learning	(Casale-Giannola, 2012)	Active learning and real-world scenarios.	Facilitated inclusion (increased participation and/or learning outcomes).	High school math, science, English, SS, health, and vocational
	(Mastropieri et al., 2006)	Collaborative hands-on activities.	Increased learning outcomes in science (includes students w/ LD).	Middle school science

Teacher Talk. Teacher talk was coded in five studies (Table 13). It included teacher modeling, think alouds, instructional talk, response prompting, questioning strategies, wait time, positive feedback, and reducing speech rate. Teacher talk was used in the general classroom and done by the classroom teacher. Some forms of teacher talk, like response prompting, were used in the general classroom but targeted certain students to increase participation (Alquraini & Gut, 2012). The studies reviewed found that teacher talk helped increase participation of all students including students with learning disabilities (Berry, 2006), Deaf and hard of hearing (DHH) students (Alasim, 2018), and students with severe disabilities (Alquraini & Gut, 2012). Teacher talk was associated with increased text comprehension for students with severe disabilities (Doğanay Bilgi & Özmen, 2014), and with decrease rates of problem behavior in all students (Trussell et al., 2016).

The results indicated that teacher talk could be a good inclusive strategy for middle school science classes. Teachers are more likely to use instructional adaptations that do not require much preparation or tailored instruction (Roy et al., 2013). Changing or increasing the quality of teacher talk is beneficial to a wide range of students. High school teachers predominantly use lecture or direct instruction, using it for 70%-78% of their teaching (McKinney & Frazier, 2008). Therefore, incorporating more teacher talk strategies could be easily integrated into a science teachers' current pedagogy and be beneficial for many students in the class.

Involvement Strategies. Five of the studies that contained teacher practices were coded as involvement strategies (Table 13), which include response cards, real life and career connections, self-assessments, and encouraging ownership. These strategies increased participation for students with intellectual disabilities (Clarke et al., 2016) and increased overall student participation including students with disabilities (Berry, 2006; Casale-Giannola, 2012; Duchaine et al., 2018). Involvement strategies were also associated with increased learning outcomes for all students (Casale-Giannola, 2012; Duchaine et al., 2018) and with increased feelings of inclusion by teachers and students (Florian & Beaton, 2018). The studies reviewed for involvement strategies were set in elementary and high schools with one set in elementary science (Clarke et al., 2016) and two in high school science (Casale-Giannola, 2012; Duchaine et al., 2018).

Results indicate that involvement strategies could be a good inclusive strategy for middle school science. Involvement strategies may take a bit more planning to use in class than some of the other teacher practices, such as teacher talk, but less than many of the larger strategies, such as universal design for learning (UDL) and differentiated instruction (DI). Some involvement strategies, such as response cards, where teachers check for understanding by asking the class a question and students respond by holding up the card (Adamson & Lewis, 2017), fit well into a lecture style class that is common in higher level science. Strategies like response cards can help students to be actively engaged during instruction and can be adopted easily without significantly changing one's pedagogy (Marmolejo et al., 2004). Thus, involvement strategies could be a good strategy for teachers beginning to integrate inclusive practices.

Cooperative Learning. Cooperative learning was coded in three of the articles (Table 13). Cooperative learning is distinct from peer assisted learning (PAL), where one student has an instructional or facilitative role. In cooperative learning, students are working together collaboratively to experience an activity or co-generate meaning. Collaborative learning in all the studies involved small learning groups within the general classroom. Studies reviewed found cooperative learning was associated with increased participation of DHH students (Alasim, 2018), increased science learning outcomes in inclusive middle school science classes (Mastropieri et al., 2006), and increased academic, social and communication outcomes for students with severe disabilities (Alquraini & Gut, 2012).

Collaborative learning can be combined with other strategies. In Mastropieri et al. (2006), the learning activity involved a collaborative, hands-on science activity. One of the strengths of cooperative learning mentioned in the articles reviewed was that collaborative learning can be done in conjunction with other strategies to facilitate inclusion (Alquraini & Gut, 2012). Cooperative learning is most often done in small groups and would take some teacher preparation and planning; however, it could be added to a teacher's current practice as one off lessons without large changes to teachers teaching style. Thus, cooperative learning could an effective relatively simple strategy to incorporate in middle school science.

Positive Culture. Creating positive culture was coded in two of the articles (Table 13). It included community building within the class (Casale-Giannola, 2012) or teaching the whole class an activity that facilitated understanding of students' differences (Alasim, 2018). From the articles reviewed, positive culture was associated with increased participation and interaction of DHH students (Alasim, 2018) and increased participation and learning outcomes in inclusive high school classes (Casale-Giannola, 2012). According to Casale-Giannola (2012), a positive culture and strong feeling of community is a great strength of vocational classes that should be better adopted in other high school programs to increase inclusion. Creating positive culture involves creating a relationship between students and between teachers and students (Casale-Giannola, 2012), thus it is something that must built and maintained throughout the year. Creating positive culture may take a bit more planning and commitment than other teacher practices, as it is something that has to be maintained throughout the year (Casale-Giannola, 20122). Results suggest that positive culture could be a beneficial strategy for middle school science.

Hands-on Learning. Hands-on learning was coded in two of the articles (Table 13). The practice included active hands-on activities. In both articles hands-on learning was associated with positive outcomes. It was found to facilitate inclusion, was associated with increased learning outcomes (Casale-Giannola, 2012), and facilitated learning of middle school science content (Mastropieri et al., 2006). Review of the articles suggests that hands-on learning is a strategy that is applicable to middle school science. According to Casale-Giannola (2012), the real-world aspect of the hands-on activity helps to increase students' interest and engagement and it is often lacking from high school content area classes. Including hands-on learning would likely involve increased teacher planning, preparation, and resources to create the activities however, once created these activities can often be re-used. Hands-on learning activities could be added to units a teacher has already planned and therefore not require a large change to a teacher's pedagogy. From the articles reviewed, hands-on activities could be useful in facilitating inclusion in middle school science.

Teacher Practices Discussion. All the teacher practices reviewed would be appropriate inclusive strategies for middle school science. Teacher practices could be useful for a teacher wanting to start making smaller changes to increase inclusion. Many teacher practices are less resource intensive than other strategies reviewed, such as universal design for learning (UDL) or differentiated instruction (DI). Adding a teacher practice strategy may be relatively easy as it may require less planning, training, and resources. For example, a teacher can increase the quality of their teacher talk by giving more wait time after asking a question or using think-alouds when demonstrating a skill. A teacher could also add cooperative learning and hands-on learning activities as stand-alone lessons to preplanned units they currently teach. Research reviewed indicates that these simple changes can benefit students learning and participation.

Teacher practices tend to include elements of larger strategies such as universal design for learning (UDL). However, teacher practices lack the breadth of the larger strategies. The teacher practice involvement strategies can increase student engagement (Duchaine et al., 2018). However, involvement strategies do not address students executive functioning skills (EF) or support students in expressing their ideas. It would be possible to choose larger strategies, such as UDL, and start with small teacher practices that help provide inclusive options with the goal of building towards the full implementation of the larger strategy. A strategy, such as UDL, is a multicomponent strategy that supports student engagement, expression and perception by using various supports which may include teacher practices (Capp, 2017).

Discussion

The research question for this project was, what are some research supported strategies that can help a teacher facilitate inclusion in middle school science? This content analysis surveyed inclusive strategies that a teacher could use to facilitate inclusion in their class. Strategies reviewed included teacher practices, strategy instruction, peer assisted learning (PAL), technology, universal design for learning (UDL), differentiated instruction (DI), collaboration, and behavior supports. The strategies were examined for use in a science class from the point of view of a learning support and science teacher. Strategies from the content analysis were then used to create inclusive resources that are included with this project.

During the content analysis many effective inclusive strategies were reviewed for use in middle school science. All strategies reviewed were found to be research-supported, inclusive strategies applicable for a middle school science class. Which strategy adopted should depend on teacher preference, the needs of the class, and available resources. For successful implementation of inclusive strategies, it is recommended that the inclusive strategies used fit with the teacher's pedagogy and personal strengths (Fleer et al., 2017). There is no one best fit strategy that will work for all teachers. Successful strategy selection is linked to teachers' pedagogical views, as teachers can have different benefits using the same strategy and have similar benefits using different strategies (Berry, 2006). Teachers must also take an active interest in using and refining the strategy. Success in adopting and sustaining inclusive practices has not been associated with years of teaching experience but with the level of teacher engagement in and reflection on inclusive practice (Garcia-Campos et al., 2018; Schnellert et al., 2008).

This project did not aim to deem one strategy as the most effective. It was clear that there are many effective strategies that teachers can choose from and teachers can choose strategies that fit with their needs and pedagogy. In this project, a variety of inclusive strategies were presented and their relevance to middle school science was discussed from the point of view of a learning support teacher and science teacher. From this vantage point, universal design for learning (UDL) was chosen to create the associated resource package.

It is my experience that students often experience multiple barriers to learning and as a teacher my goal increase access for as many students as possible. Choosing one small strategy, such as a teacher practice, can help some students some of the time, however choosing a larger more encompassing strategy can work to reduce multiple barriers to learning. UDL was chosen as the inclusive strategy for the resources associated with this project because as a learning support teacher, science teacher, and researcher I felt UDL had the potential to best facilitate inclusion. UDL has a flexibility and breadth that I did not find in other strategies. The principles of UDL (Table 1) are designed to meet diverse range of students' needs. UDL can include any of the strategies presented in this project, such as technology, collaboration, teacher practices, differentiated instruction, peer assisted learning (PAL), cooperative learning, and strategy instruction. The strategies reviewed could be used to achieve one or more of three principles of UDL (providing multiple means of engagement, representation, and action and expression). UDL encompasses good planning, supports executive functioning skills (EF) and encourages community building which were highlighted during this project as important for inclusion. UDL is best used class-wide and can require fewer individual adaptations. It can also help a teacher add breadth to their classroom and not become stuck using one type of inclusive strategy.

UDL was chosen for the associated resources because I felt it had the largest potential to reduce multiple barriers for learning and increase inclusion. UDL was chosen because of its potential as an inclusive strategy, its breadth, and its flexibility. Depending on the activity and the needs of the class, a teacher using UDL could utilize any of the inclusive practices found in the content analysis. The UDL principles can help teachers ensure they are using a breadth of strategies throughout the year. Using UDL allows teachers to provide a variety of inclusive strategies which is important as it can support a diverse range of students and allow for flexibility and creativity when planning. UDL was also chosen because of its focus on and potential to develop EF skills, which is very important for middle school students. A large part of the UDL principle is to 'provide multiple means of action and expression' and focuses on EF development. As an inclusive strategy, UDL has great potential in the middle school science class. However, before UDL becomes a sustained practice, teachers need experience implementing UDL in their classrooms (Courey et al., 2012). The associated resources in this project aim to give science teachers experience with using UDL.

Limitations

The purpose of this content analysis was to highlight effective inclusive strategies for middle school science. Strategies were analyzed primarily on prevalence and on how I, a science and learning support teacher, feel they would work in a middle school science class. This means that my analysis is biased towards my professional opinions and preferences. For example, I found that targeted supports that make students feel different are rarely used by middle school students (even those who need them) and that most if not all middle school students would benefit from EF supports. During my master's degree and teaching experiences, I developed a preference for class-wide strategies that support all students while making workloads on teachers reasonable. These types of supports are more sustainable for teachers and build class community. I do not claim that any strategy reviewed in this project is the best for all teachers and all classes. However, universal design for learning (UDL) has the biggest potential to reduce multiple barriers to learning and the strategy I would choose for my middle school science class.

Directed Literature Review

The following is a directed literature review on the findings from the content analysis to further investigate the strategies to be used in the inclusive resources. Universal design for learning (UDL) with a focus on executive functioning skills (EF) was the chosen strategy for the development of the inclusive resources. A directed literature review, as described by Creswell (2015), is helpful in this instance because it helps explore the chosen strategies more deeply.

Universal Design for Learning (UDL)

UDL is based on three underlying principles of providing: multiple means of engagement, multiple means of representation and multiple means of action and expression (Meyer et al., 2016). These main principles each have three associated guidelines: to provide multiple means of engagement a teacher should provide options for recruiting interest, sustaining effort and persistence, and self regulation; to provide multiple means of representation a teacher should provide options for perception, language and symbols, and comprehension; to provide multiple means of action and expression a teacher should provide options for physical action, expression and communication, and executive functions (Meyer et al., 2016). Then these guidelines have associated checkpoints for a teacher to refer to for more specific information (Table 1). Each principle should be incorporated in each class and teachers should use the guidelines and checkpoints to ensure they are providing a breadth of options. Following the UDL guidelines helps teachers to shape instructional goals, assessments, methods, and materials that are meaningful and accessible to all students (Meyer et al., 2016). Planning using UDL reduces barriers and gives maximum opportunity to build knowledge (Capp, 2017; Courey et al., 2012). Rather than targeting students working at grade level and then providing extensions for high achievers and reductions for struggling students, UDL emphasizes the importance of planning for the natural variability of learners (Meyer et al., 2014). Options are given to students each class, so learning is accessible and meaningful to them. The intention of UDL is to design accessible content and learning environments to improve the learning experience of all students regardless of learning abilities.

UDL in Conjunction with other Inclusive Strategies

UDL is a flexible framework that is intended to be used in conjunction with multiple inclusive strategies. No one strategy or tool will work for all students, so it is important to provide a range of options (Hitchcock et al., 2016). The key principles of UDL are achieved by using a variety of strategies and tools many of which were found in the content analysis associated with this project.

The first UDL principle of providing multiple means of engagement involves motivating learners, creating interest, and increasing effort, persistence, and self-regulated learning (Meyer et al., 2014). Student engagement can be supported with a multitude of research supported strategies such as technology (Table 7), peer assisted learning (PAL) (Table 8), as well as teacher practices such as involvement strategies, teacher talk, cooperative learning, and hands-on learning (Table 13). The UDL principle of supporting engagement can help teachers move away from lecture dominant instruction and deliver content through other means (Al-Azawei et al., 2016).

To start using UDL, a teacher would think about the big idea of the unit. The big idea must be accessible to all students and should follow the BC curriculum. For example, for the grade nine life science unit, the big idea could be that cells come from other cells. All learners should be able to understand this idea, it can be accessed and explored in many ways, and to differing depths. The teacher then thinks about how to provide multiple means of engagement. How will they provide options for recruiting interest? They could optimize choice and autonomy by having students chose an organism and explore how it reproduces. Students could have choice in what they study, how they study it, and how information is presented. As the teacher plans the unit many more UDL guidelines should be included. There may not be a specific rubric that teachers can use to assess all learners in the same way, but there can be a general rubric that allows teachers to track and asses students progress on the big idea of the unit.

The second UDL principle of providing multiple means of representation is associated with the methods by which information is presented so it is usable by all learners (Meyer et al., 2014). Students in the class will vary in how they learn best. Providing multiple means of representation can increase engagement and broader access to concepts (Capp, 2017; Hitchcock et al., 2016). Students must construct knowledge from information presented to learn, this involves perceiving, understanding, integrating, and manipulating information (Meyer et al., 2016). Providing options for representation can involve providing options for perception, options for language (and symbols) and options for comprehension (Meyer et al., 2014). Providing multiple means of representation can be addressed through multiple strategies such as strategy instruction (Table 6), technology use (Table 7), peer assisted learning (PAL) (Table 8), collaborating with special educators (Table 11), and teacher practices such as hands-on activities and cooperative learning (Table 13).

To provide multiple means of representation the teacher would think about the big idea of the unit, for the grade nine life science unit this was that cells come from other cells. The teacher thinks about how to provide multiple means of representation in regard to the big idea. One way to provide options for perception would be to have the students choose ways to access information (i.e. videos, books, direct observations, hands-on activities, audio clips, magazines etc.). The students could then learn about how their organism reproduces using the means that they chose. The teacher could clarify language and symbols that are important to understand the big idea. This may include vocabulary activities to increase familiarity of words that are important for the big idea such as reproduction, cell, DNA, asexual, etc. In this principle of UDL, it is also important to activate and provide background knowledge to help students transfer and build knowledge (Meyer et al., 2014). Building and supplying background knowledge can be achieved in many ways such as with video clips or brainstorming activities.

The final principle of UDL is providing multiple means of action and expression. This involves supporting the development of executive functioning skills (EF), providing options for expression and communication as well as providing options for physical action (Meyer et al., 2014). Applying multiple means of action and expression allows students to demonstrate their learning in different ways. Supporting and developing EF are important when supporting action and expression. EF include goal setting, progress monitoring, adjusting approaches, strategy development and managing information. EF are important when students are navigating a learning environment and communicating and representing knowledge. Means to support expression, communication, physical action, and EF could include strategy instruction (Table 6), cooperative learning (Table 13), or technology (Table 7).

To use this principle in our grade nine life science example the teacher would give options for action and expression. Throughout the lesson and unit, the teacher would use this principle when they support students' executive functioning skills (EF). Supporting EF can be done by helping students learn to set goals, plan their time, and monitor their progress towards their goals. The principle of action and expression also includes giving students options for showing their learning. This could be achieved by providing options for expression and communication, where students chose a means to present what they know. For example, in life science, students could present their learning in a project on how an organism reproduce orx talk about an organism, create a visual (model, poster, PowerPoint presentation, or video clip), write an essay, or use technology.

UDL is a framework that guides the design of classroom learning activities. UDL is comprised of three main principles of providing multiple means of engagement, action and expression, and representation. These principles help teachers plan lessons and activities to help all students access and participate in meaningful learning activities.

Executive Functioning (EF)

EF supports are one way to support inclusion in the UDL framework in the middle school science classroom. EF skills have been linked to success in school and life, therefore important for students to develop these skills (DuPaul & Weyandt, 2006), such as paying attention, staying organised, understanding information, or staying calm.

Many students struggle in middle school because they lack the EF skills to be successful (Denckla, 2007). In elementary school, teachers often support students' EF skills more than in middle and high school (Denckla, 2007). In my experience, elementary school teachers often use calendars and class schedules, communicate with parents, use planners, help students organize their desks, set up their pages/projects, and provide structure in activities to support students' EF. It is also my experience that when students enter middle and high school, many of these EF supports are absent. Some middle and high school teachers assume a level of EF competence above what is realistic for many students (Denckla, 2007; Fisher & Daley, 2007). This means that students who were successful in elementary school can struggle greatly in middle school because of the increased EF demands and lack of supports (Denckla, 2007). This can be a major barrier for many students which may lead to being mislabelled as having behaviour challenges rather than being neurodevelopmentally less mature (Denckla, 2007).

EF supports can be embedded in strategy instruction targeting an academic skill (see strategy instruction in Awada & Plana, 2018; Cihak & Castle, 2011; Hitchcock et al., 2016) and in regular class work when the teacher applies EF support guidelines or frameworks (Cooper-Kahn & Foster, 2013; Jacob & Parkinson, 2015; Meltzer, 2010). Some research suggests that teachers should not use “one off” lessons because they are best developed by embedding these strategies into daily teaching (Gaskins & Pressley, 2007; Meltzer et al., 2007; Rose & Rose, 2007). Using EF support strategies class wide are effective in developing students’ EF (Fleer et al., 2017; Humphries et al. 2004; Rose & Rose, 2007; Thorell et al., 2009). In middle school, there are increased demands for organisation, task completion, attention, and self-regulation (Denckla, 2007). Because of these increased demands, it is important to teach organization, study skills, self-management, as well as involve students in the planning and implementation of behavior-change strategies (DuPaul & Weyandt, 2006).

Planning using the universal design for learning (UDL) guidelines (Table 1) helps embed EF strategies in class (Brownlie et al., 2011) because EF supports are essential to a well-designed UDL classroom (Meyer et al., 2016). Similar elements are often recommended to target EF development such as: predictable routines, step-wise guides, clear expectations, logical sequencing of material and the use of visuals (Cooper-Khan & Foster, 2013; Humphries et al., 2004; Jacob & Parkinson, 2015; Thompson, 1997), as well as, repeated teacher modelling (Rosenshine & Meister, 1994), and think alouds (Fisher, 2002). Direct and explicit instruction is also recommended to develop EF (Cooper-Kahn & Foster, 2013; Jacob & Parkinson, 2015; Meltzer, 2010). Research highlights the importance of direct, explicit strategy instruction because it increases understanding, promotes metacognition, and allows for the transfer and creative use of knowledge (Gaskins & Pressley, 2007; Rosenshine & Meister, 1994). The research reviewed shows that explicit instruction can not only help students develop their EF but also metacognitive strategies to learn more efficiently and easily (Fisher, 2002; Gaskins &

Pressley, 2007). A well designed UDL classroom has the EF support elements previously noted (Meltzer et al., 2007). Following the UDL framework allows a teacher to embed EF strategies in each class for all students in a consistent way (Brownlie et al., 2011; Moore, 2018).

There are many strategies a teacher can use to help support students with low EF. Many recommendations align with inclusive strategies reviewed in the content analysis section of this project. Strategies from the content analysis that target EF are strategy instruction (Table 6), universal design for learning (UDL) (Table 10), and teacher practices (Table 13) benefit all students. Diamond and Lee (2011) postulate that the most effective way to improve EF is not to focus on EF in isolation but address students holistically. Addressing students emotional, social, and physical development at the same time may help increase EF (Diamond & Lee, 2011).

Strategies and Resources for the Attached Inclusive Resources

In this section, planning resources by Shelley Moore (Moore, 2019) are examined for use in the associated inclusive resources. Moore's (2019) resources were chosen for this project because she is an expert in inclusion, her resources are based in universal design for learning (UDL), and she is currently known in the school district where these resources are used.

Moore is a Social Sciences and Humanities Research Council funded PhD candidate at the University of British Columbia. Her research focuses on inclusive education for students with significant disabilities in secondary schools. She is also an educational consultant who works with school districts to increase their use of effective research based inclusive practices. Moore has facilitated a series of workshops in my school district on supporting inclusion in the general classroom. The workshops series, Inclusive Classroom Strategies and the New Curriculum, was part of the Transforming Inclusive Education Professional Development Series, presented in Courtenay, BC in 2018-2019. During these workshops, Moore presented planning supports and strategies based in UDL that can help teachers support all students (Moore, 2019). These templates are available on her website at https://blogsomemoore.com/.

Moore (2019) recommends using UDL and she uses this strategy as part of her planning and teaching resources. Fundamental to UDL, Moore (2019) also suggests creating learning opportunities that are intentional, purposeful, and planned. It has been shown that promoting student self-management and metacognition can increase learning (Donker, et al., 2014; DuPaul & Weyandt, 2006). Moore (2019) recommends using adjustable curriculum, supports, and assessments in the classroom and recommends teachers to consider how students can make their own adjustments to their learning when they need them.

Using Moore's (2019) templates a teacher plans for common variation found in most classes. A teacher can go beyond planning for common variation and target specific needs in their classes. Having a better understanding of the strengths and stretches of learners can help a teacher plan more effectively (Moore, 2018). Moore describes the strengths and needs of her class and individuals to create a class profile. A class profile can be completed in collaboration with special education teachers, past teachers, counselors, students and/or parents. Creating the creating profile is often done at the beginning of the year and updated throughout the year. It is recommend for teachers to complete a class profile when using the associated resources found in this project. A class profile template is provided in the associated resources.

Moore's (2019) unit and lesson planning templates encourage a teacher to use UDL and start planning from a big idea that is accessible to all students in the class. Using backwards design and planning from big ideas, using UDL principles, resulted in effective lesson plans for high school general classes (Young & Luttenegger, 2014) and science classes (Hitchcock et al., 2016; Spaulding & Flannagan, 2012; Watt et al., 2013). Moore (2019) recommends starting with high standards for all and applying flexible challenges by using an accessible task table (Table 14). In the accessible task table, there are a range of goals that increase in complexity. Everyone must complete the first goal, which is the access goal. The task table is presented to students at the beginning of class. Students are encouraged to use the task table during class and work to complete as many of the goals as they are able to.

Table 14

Accessible Task Table

Processing Tasks →				
I need to… Access	I must… All	I can … Most	I could… Few	I can try to… Challenge

Adapted from Moore, (2019)

The access goal is presented to students with the student first language of "I need to" and which increases to, "I can," and "I can try to." The access goal for the class is an inclusive one. All students in the class should be able to complete the access goal or else the goal needs to be redesigned. The intention is not for students to complete all goals, but for students to be appropriately challenged. Access goals ensure students with exceptionalities are completing activities that the whole class is engaging in. Students with exceptionalities are not doing special activities or parallel work. This expectation of access for all and lesson design that increases in complexity allow students to take responsibility for their learning and adjust goals to their abilities.

Moore (2019) recommends planning for essential supports (i.e. useful for few, such as a braille textbook), targeted supports (i.e. useful for some, such as an audiobook), and universal supports (i.e. useful for all, such as visuals). Moore also recommends having supports available for all. In this way, a teacher can ensure they are providing essential individual supports for those who need them and all students have access to these supports. Students have some responsibility and control over their learning as they may choose supports and goals to meet their learning needs. This idea of students adjusting their goals and supports is also fundamental to UDL. What is essential for some students is likely beneficial for other students, therefore all supports should be available for all students (Meyer et al., 2014).

Moore's (2019) templates are practical tools to help implement the UDL framework. Her templates provide a practical, flexible way to plan with UDL, which can be used in any subject or grade level, and used in conjunction with other inclusive strategies identified in this project. The templates are available online at https://blogsomemoore.com/shout-outs/templates/.

Encouraging Reflective Practice

The inclusive resources provided at the end of this project are intended to help middle school science teachers to adopt and develop inclusive practices. Transforming one's practice can be supported through teacher reflection. Teacher training in inclusive practices that promote reflection have been found to reduce barriers to learning and increase student participation (Garcia-Campos et al., 2018). Reflective practice can help teachers continue with and improve the implementation of inclusive strategies in their classes (Schnellert et al., 2008). According to Schnellert et al. (2008), the extent to which inclusive practices are embedded and sustained is associated with regular collaborative reflection. Reflective practice is considered an essential part of a teacher's practice (Atkins & Murphy, 1993; Sen & Ford 2009; Thompson & Pascal, 2012). A teacher can deepen their understanding of their practice by engaging in reflection (Somerville & Keeling; 2004), because reflection helps promote continuous learning and integration of theory and practice (Ganly, 2017). Reflective practice is also important when undergoing educational change (Kumpulainen et al., 2018) and practitioners become advocates (Thompson & Pascal, 2012).

Teacher reflection may be very important while a teacher is learning to use inclusive strategies (Lyons et al., 2016; Schnellert et al., 2008; Thompson & Pascal, 2012). Teacher reflection is encouraged in the associated inclusive resources because it helps teachers to develop and grow in their practice. To promote refection, Driscoll (1994) uses a three-question model for reflection, which are also used in the associated inclusive resources. The model is based on Kolb's (1984) experiential learning cycle of action and reflection. The reflective questions include: 'What?' – describe the experience; 'So what?' – describe why this learning was important; and 'Now what?' – describe your next step in your professional development. These three questions are incorporated into the associated inclusive resources to promote teacher reflection. Reflection not only involves learning from experience but also going beyond the experience to create new knowledge (Dewey, 1960). The aim of the project to encourage middle school science teachers to not only try inclusive strategies in their classes but to have them engage with and adapt inclusive strategies for their own use.

Summary

After a review of literature on evidence-based strategies to support inclusion, universal design for learning (UDL) was chosen as an overarching strategy to use to create associated inclusive resources for teachers to support inclusion in middle school science classes. The unit and lesson plan format used in the resources was adapted from Shelley Moore's workshop series, Inclusive Classroom Strategies and the New Curriculum in the Transforming Inclusive Education Professional Development Series (Moore, 2019). This project is ontologically rooted in postmodern relativism; that truth is built based on experience and there is no one truth or reality (Mayan,2009). These associated inclusive resources suggest one way a teacher could incorporate inclusive strategies in their middle school science classes. These resources are intended to be starting point for middle school science teachers to try out and experiment with. The experience of one teacher differs from that of another. The inclusive strategies they choose and how they are used may also differ. It is the hope of this project that middle school science teachers engage with inclusive strategies and develop their practice. Within the provided unit and lesson plans in the associated inclusive resources, teachers are encouraged to engage in teacher reflection while they implement and develop inclusive strategies.

Facilitating inclusion involves effort and commitment on the part of the teacher. Research suggests that it could take three years for a teacher to be proficient in adopting new strategies (Rose & Rose, 2007). There is no simple straight forward path to fostering inclusion, however, the associated inclusive resources developed in this project for middle school science teachers will be made available for science teachers at my school and district soon after the completion of this project with the hope that teachers will use inclusive strategies that work for them and their students.

Part Three: Working Smarter not Harder Inclusive Lessons for Middle School Science

From my experience as a science and special education teacher, I see a need for inclusive resources for middle and high school science classes. Many students could benefit academically and socially as teachers gain knowledge and confidence using inclusive strategies. Many science classes today closely resemble those of very long ago. Lecture style instruction can dominate and there can be an emphasis on memorization and high stakes testing. This is changing, especially with the introduction of the new curriculum in BC which is intentionally inclusive and focuses on big ideas. From the new curriculum and from the shift towards inclusion, many teachers may agree in principle with inclusion but may lack confidence and experience facilitating it.

From the content analysis, there are many inclusive strategies a teacher can use within their middle school science classroom. Strategies included strategy instruction, technology, peer assisted learning (PAL), differentiated instruction (DI), universal design for learning (UDL), collaboration, behaviour supports, and teacher practices. These strategies were identified as effective based on different measures, but this project does not deem one strategy more effective than another. However, while examining these strategies, I concluded that UDL was the strategy that I would use to develop the associated inclusive resources. UDL can support inclusion in a multifaceted way and can be used by any teacher in a way that fits with the teachers strengths, the resources they have, and the needs/challenges of each individual student and class.

I have named this program '*Working Smarter not Harder'* because it is my intention to help teachers try out and hopefully adopt practical, sustainable inclusive practices. This program was designed to help increase inclusion in a science 8 class. The resources contain an inclusive science unit; it was designed not only to support students but also to support teachers to use and develop inclusive strategies.

Description of Program

This program consists of a Chemistry 8 unit. The unit consists of a unit plan, eight lesson plans, and associated handouts and materials. The unit plan includes a detailed description of each portion of the lesson plans as well as advice on how to implement the lessons. The focus of the unit is chemistry because it is an abstract topic and I have found that it is often taught through lecture style direct instruction. The intent is to provide alternatives for traditionally content heavy lectures and promote inclusive teaching strategies to increase access to learning for all students.

The resources were designed using universal design for learning (UDL) guided by Shelley Moore's lesson and unit planning templates (Moore, 2019). Each principle of UDL was intentionally used each lesson and is highlighted. Strategies from the associated content analysis were also included when they helped achieve the UDL principles. Supports to develop executive functioning skills (EF) were also intentionally included and run throughout the unit.

The intention of the resources is to give concrete examples of planning using UDL; how to provide multiple means of engagement, representation, and action and expression. Teachers can use these resources and adapt and build upon them. It is my hope that teachers try out and adopt practical, sustainable inclusive strategies like those presented here and support the learning of all of their students in middle school science.

Chemistry 8 Unit Plan

This introduction to chemistry unit was planned using principles of universal design for learning (UDL) and backwards design. Big ideas for the unit were highlighted and made more accessible by connecting ideas and simplifying vocabulary. They were then separated into guiding questions and "I can' statements which were used to plan each individual lesson.

This unit is intended for middle school grade eight science classes. The unit consists of eight lesson plans including an assessment of learning culminating activity. Following each lesson and attached as appendices are all associated worksheets, presentations, and handouts. These resources are available as editable/fillable Word and PowerPoint documents in the appendices or by emailing the author. Providing fillable documents allows teachers to tailor the resources to meet their needs and allows students to complete the documents using assistive technology.

When using these resources keep in mind that each class is unique in abilities, interests, and social dynamics. It is important to collaborate with specialist teachers (counsellors, learning support teachers etc.) as well as students to understand students' needs and abilities. Some students may have Individualized Education Plans (IEPs) or Learning Plans which can impact goals for the course and give information to help teachers understand and support students. However, it is also important to realize that assistive technology, adaptations, and other inclusive practices can have benefits for all students and are more likely to be used by those who need them if they are available for all.

Big Ideas from BC Curriculum

- Big Idea: The behaviour of matter can be explained by the Kinetic Molecular Theory (KMT) and Atomic Theory
- Content: KMT, Atomic Theory, protons, neutrons and quarks, electrons, and leptons

Accessible Big Idea

- The behaviour of matter can be explained by its particles

Unit Guiding Questions

The accessible big idea was used as the foundation for this unit. All lessons link back to this idea and are broken down into guiding questions and sub-statements which are accessible allowing varying depth of study. The overarching idea pertains to how particles explain the behaviour of matter. This was broken into two main questions and then further broken into many statements.

1. Why does matter change state?
    - I understand matter is anything that has mass and volume.
    - I understand there are different states (phases) of matter (solid, liquid and gas).
    - I can classify matter into 3 states (solid, liquid or gas).
    - I understand that matter is made of small particles.
    - I understand that the particles in solids, liquids and gases have different energy, movement, and spaces between particles.
    - I understand that matter can change state.
    - I can predict changes of state that will occur when heat is added or taken away.
    - I understand that changes in energy (heat) cause changes in particle movement which causes a change of state.
2. How do particles (subatomic) explain properties of matter?
    - I understand atoms are the smallest components of an element with its properties.
    - I understand atoms are made of smaller particles.
    - I can represent the parts of an atom according to atomic theory (protons, neutrons, and electrons).
    - I can identify models of the atom.
    - I can represent an atom.

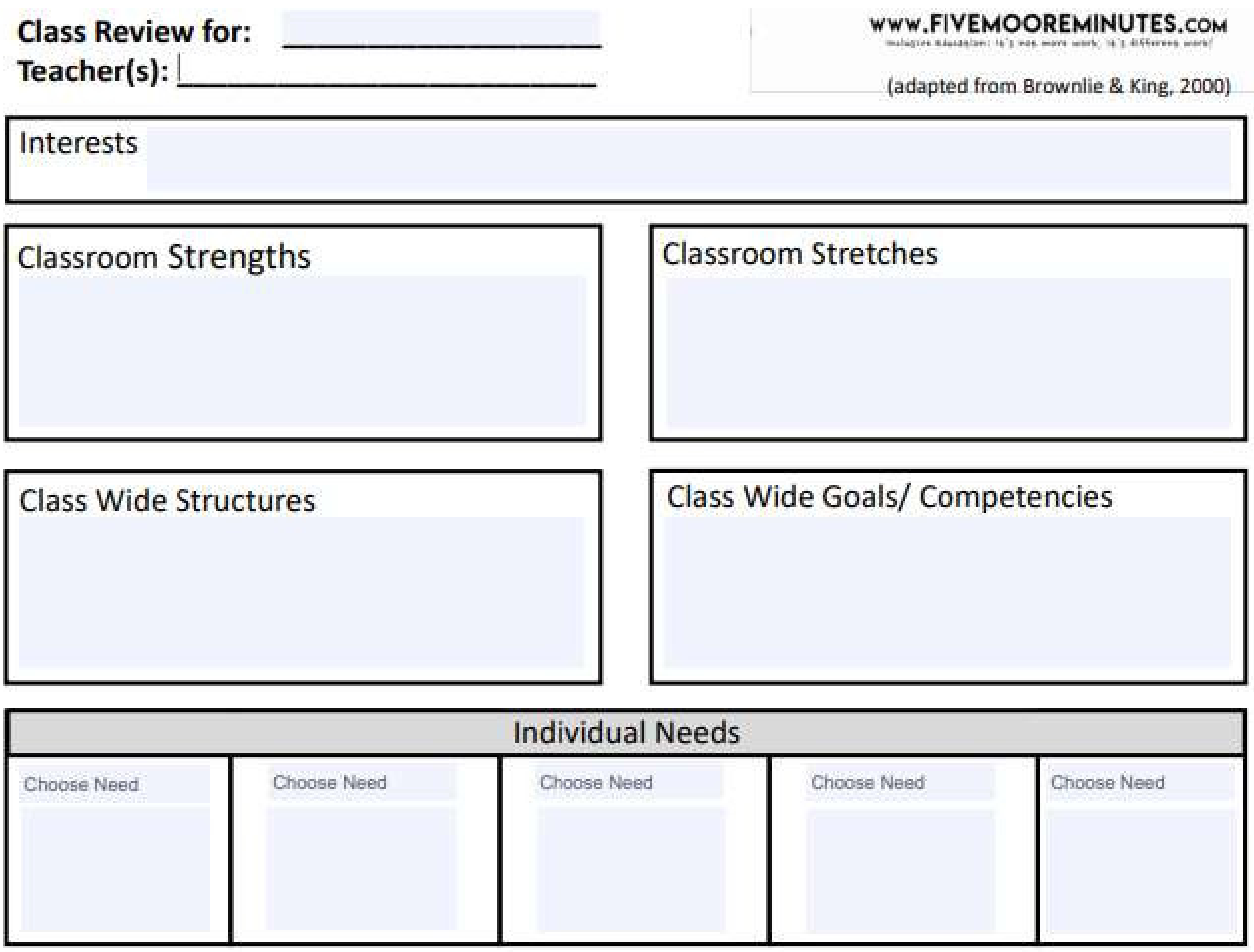
- I understand that atomic structure effects the behaviour of matter. For example, I understand that proton number defines the element, neutrons are associated with mass and electrons with charge.
- I can identify physical and chemical changes.
- I understand how particles are responsible for the characteristics of matter.

Class Profile

It is important to plan for the variation within a class when using UDL. This can best be done by collecting information about the strengths, stretches and interests of the class. Although there was no class to profile for these resources Moore's (2018) template is included for teachers to use (see Figure 1). This template is available as an editable document at https://blogsomemoore.files.wordpress.com/2019/05/class-review-pdf-editable.pdf. A class profile is usually done at the beginning of the year but can be more meaningful if teachers add to it as students develop and teachers understanding of students change. It can be helpful to collaborate with students past teachers, special education teachers, counsellors, parents and/or students for the class profile. Teachers can also have students complete a profile on themselves at the start of the year. This can give a lot of information and can be done again later in the year to show growth or change.

Figure 1

Class Profile



Class Review for: ____________________

Teacher(s): ____________________

www.FIVEMOOREMINUTES.com

(adapted from Brownlie & King, 2000)

Interests

Classroom Strengths

Classroom Stretches

Class Wide Structures

Class Wide Goals/ Competencies

Individual Needs

Choose Need

Choose Need

Choose Need

Choose Need

Choose Need

(Moore, 2018)

Universal Design for Learning (UDL)

Each Lesson was planned with backwards design and UDL. The principles, guidelines and checkpoints used in each lesson will be listed at the beginning of each lesson plan. For reference they are listed in Table 15. However, the UDL principles that are in every lesson (Moore's (2019) accessible Task Table (Table 16), fillable forms and those associated with planning) will not be listed in each lesson as they are discussed here and are then assumed.

Table 15

UDL Guidelines

Principles	**Provide multiple means of Representation**	**Provide multiple means of Action and Expression**	**Provide multiple means of Engagement**
Guidelines and Checkpoints	Provide options for perception: Offer ways of customizing the display of information. Offer alternatives for auditory information. Offer alternatives for visual information.	Provide options for physical action: Vary the methods for response and navigation. Optimize access to tools and assistive technologies.	Provide options for recruiting interest: Optimize individual choice and autonomy. Optimize relevance, value, and authenticity. Minimize threats and distractions.
	Provide options for language and symbols: Clarify vocabulary and symbols. Clarify syntax and structure. Support decoding of text, mathematical notation, and symbols. Promote understanding across languages. Illustrate through multiple media.	Provide options for expression and communication: Use multiple media for communication. Use multiple tools for construction and composition. Build fluencies with graduated levels of support for practice and performance	Provide options for sustaining effort and persistence: Heighten salience of goals and objectives. Vary demands and resources to optimize challenge. Foster collaboration and community. Increase mastery-oriented feedback.
	Provide options for comprehension: Activate or supply background knowledge. Highlight patterns, critical features, big ideas, and relationships. Guide information processing and visualization. Maximize transfer and generalization.	Provide options for executive functions: Guide appropriate goal setting. Support planning and strategy development. Facilitate managing information and resources. Enhance capacity for monitoring progress.	Provide options for self-regulation: Promote expectations and beliefs that optimize motivation. Facilitate personal coping skills and strategies. Develop self-assessment and reflection.

Adapted from Meyer et al., (2014)

Assessable Entry Points and Increasing Difficulty

To foster inclusion, it is important to appropriately challenge a range of different learners. This can be done by providing an accessible entry point or 'access' task that all can understand and complete then increasing complexity of tasks so all students can be challenged appropriately.

For each lesson, the entry point and as well as the options for increased challenge will be listed in an accessible task table (Table 16). Students will be shown the tasks table for each lesson and asked to work towards a goal that challenges them. This self-assessment gives students some ownership over their learning and can help with goal setting and development of Executive Functions (EF). This approach of students choosing a point of access helps embed universal design for learning (UDL) principles in all lessons. Using the task table can provide multiple means of action and expression by providing options for EF (e.g. guiding appropriate goal setting, supporting planning and strategy development, and enhancing capacity for monitoring progress. Using the task table can provide multiple means of engagement by provide options for sustaining effort and persistence by heightening salience of goals and objectives and by varying demands and resources to optimize challenge. Using the task table can also provide options for self-regulation by promoting expectations and beliefs that optimize motivation and facilitating personal coping skills and strategies.

Table 16:

Accessible Task Table

Processing Tasks ⟶				
I need to… Access	I must… All	I can … Most	I could… Few	I can try to… Challenge

Adapted from Moore, (2019)

Student Goal Setting and Reflection

Each lesson asks the students to set goals for the class and reflect on how they did. At the most basic of level students would look at the task table and try to complete as much as they were able. However, students will benefit most if they are taught how to set appropriate goals (measurable, achievable, and appropriately challenging) and given time to assess and work on these goals. Individual goals will vary greatly, some students may have goals from their IEP that they are working on while some may be working on self-regulation, task-initiation, or other goals. This is a good time to address difficulties within the classroom. If a student has a chronic difficulty getting started on a task, or a student would benefit from using an assistive technology but lacks experience, this could be the opportunity to help set some goals to improve in these areas. It is recommended that teachers spend time teaching students a goal setting strategy and reviewing this strategy often. There are many strategies available and the teacher should choose a strategy that works for their class, I have a preference for those of Sarah Ward which can be found at: https://efpractice.com/index.php/25-team/94-sarah-ward-ms-ccc-slp.

Supporting and developing student planning and reflection is also an aspect of UDL. It can help provide multiple means of action and expression by providing options for executive functions: by guiding appropriate goal setting, supporting planning and strategy development, and enhancing capacity for monitoring progress. It can also help provide multiple means of engagement by provide options for recruiting interest and by optimizing individual choice and autonomy. It can also provide options for sustaining effort and persistence by heightening salience of goals and objectives and varying demands and resources to optimize challenge. Finally, it can provide options for self-regulation by promoting expectations and beliefs that optimize motivation, facilitating personal coping skills and strategies and developing self-assessment and reflection.

Teacher Reflection

Reflecting on inclusive practice can help teachers sustain and improve on inclusive practices. At the end of each lesson plan the teacher will be asked to reflect on what they did (what?), how it went (so what?) and what they would do in the future (now what?). The intention of these resources is not to be 'the way' to teach middle school chemistry, rather they are intended to give teachers experience and options with some inclusive practices.

Unit Outline

1. Lesson One: Introduction. This lesson goes over vocabulary and ideas used throughout the unit.
2. Lesson Two: States of Matter. The lesson review and builds on ideas of states of matter and the particle model of matter. Students predict changes of state and work to understand them from a particle level.
3. Lesson Three: KMT. Students expand their knowledge of changes of state from a particle level.
4. Lesson Four: Models of the Atom. Students start to learn about particles that make up the atom. They explore how our understanding of atoms has changed over time.
5. Lesson Five: Atomic Theory. Students extend their understanding of subatomic particles.
6. Lesson Six: Chemical Reactions and Properties. Chemical and physical changes are explored.
7. Lesson Seven: Making Connections. Students connect ideas from throughout the unit. Editable
8. Lesson Eight: Assessment of Learning. Students demonstrate their learning as to how particles influence matter.

Lesson One- Introduction

BC Curriculum Content: The behavior of matter can be explained by the KMT.	**Unit Guiding Question:** Why does matter change state?

Lesson Goals:
- I understand matter is anything that has mass and volume.
- I understand there are different states (phases) of matter (solid, liquid and gas).
- I understand that matter is made of particles.
- I understand that matter can change state.

UDL Checkpoints:
Multiple means of representation:
Provide options for perception: Offer ways of customizing the display of information. Offer alternatives for auditory information. Offer alternatives for visual information. Provide options for language and symbols: Clarify vocabulary. Provide options for comprehension: activate or supply background knowledge.
Multiple means of action and expression:
Provide options for expression and communication: Use multiple media for communication. Use multiple tools for construction and composition.
Multiple means of engagement:
Provide options for sustaining effort and persistence: Vary demands and resources to optimize challenge. Foster collaboration.

Processing Tasks →				
I need to… *Understand solids, liquids, and gasses change state* Access	I must… *Explain 3 changes of state in my own words* All	I can … *Understand all changes of state* Most	I could… *Learn about the fourth state of matter; plasma.* Few	I can try to… *Define and understand changes of state to and from plasma.* Challenge

Lesson Rationale

This lesson helps connect past knowledge about states of matter to the current unit as well as refresh and build this knowledge in students who need it. This lesson reviews and introduces key ideas and vocabulary that is the base for the rest of unit. Recalling about states of matter in the first step in connecting what students can observe in the physical world to the invisible particles within matter. Students should have an understanding regarding matter; the three states of matter and the particle model of matter. They will learn ideas and terminology for the changes of state as well as KMT which explains these changes from a particle level. Science contains a lot of topic specific vocabulary; it is important to explain and review terminology. This lesson gives the opportunity to review or build familiarly with some of this vocabulary. Key vocabulary include: matter, mass, volume, solid, liquid, gas, particles/molecules, movement, freezing/solidification, melting, evaporation, condensation, sublimation, deposition, change of state, energy, temperature, heat, energy, KMT. All resources are attached to this lesson plan and available as fillable documents in Appendix A.

Student Goal Setting

Have students check-in as to how they are doing today. Show students the tasks for today. The goal is to do as many can, which is different for each student and can change based on how they are doing and the tasks. Have students think about how last class went and have them set a goal for today. The teacher should check in with students who are working on specific goals (perhaps from a consultation counselor, LST or school-based team). If there are students who are having consistent difficulties in class, it may help to collaborate with others about the student and collaborate with the student as to daily goals. The teacher could have students set goals after the prior knowledge task depending on when it makes the most sense for their class.

Assessing/Activating Prior Knowledge

- Have students work independently to list what they recall about states of matter.
- Using the brainstorming pages (Figure 1), have students work in small groups share and extend the lists they have made. The teacher can circulate room to listen and perhaps hear any misconceptions. If a group is stuck the teacher could ask or project a few questions such as: give examples of each state of matter. What does it look like? Draw a picture of it. How does it move?
- Call students together to create summary list. Clarify any misconceptions.

Building Knowledge

- Vocabulary Activity: Have the students fill in Frayer Vocabulary models (Figure 2) for solid, liquid and gas using the textbook or online videos (https://www.youtube.com/watch?v=k3SJuozgbfU ; https://www.youtube.com/watch?v=wclY8F-UoTE) or other sources (https://www.chem.purdue.edu/gchelp/liquids/character.html). Adapted versions of the Frayer Model which contain the textbook definition are also included. Giving some students the definition allows them more time to draw a diagram and put the definition in their own words. Alternatively, completed sheets can be given and students who can highlight important vocabulary. Review the vocabulary as a class to ensure everyone has the main ideas. Like all documents in this resource package, the document can be completed using technology (text-to- speech, speech-to-text and or typed).
- Students should also be introduced to the terminology 'Kinetic Molecular Theory' the following video can be shown https://www.youtube.com/watch?v=1Jtw8g795Us. Then students can work in small groups to make a new title or definition for the theory in their own words. Students can then share their ideas with others (for example: put two groups together and have one group explain their ideas and one group listen then switch roles).
- Have students fill out the graphic organizer on vocabulary for changes of state using the textbook, or online sources. Review as a class.
- As a challenge, students could fill out a Frayer Model on plasma and look up changes of state to and from plasma.

Assessment of Learning

Use the Frayer models as an exit slip to check students understanding. Before student leave (and/or at the beginning of the next class) clarify any misconceptions.

Student Reflection

Have students reflect on how they did today. What did they do well? Did they achieve their goal? What could they change next time? This is be a good time to check-in with students who are having difficulties and help them with goal setting. The focus of this is to develop a growth mindset in students and teachers; effort can increase performance and help achieve goals.

Teacher Reflection

- What? What part of the lesson did you use? Did you change, add, or remove anything to the lesson?
- So what? Do you feel the resources helped foster inclusion? Increased motivation, allowed for many students to participate and learn?
- Now what? What would you do differently next time? Are there any aspects of the lesson you will continue to use?

Lesson One Resources

Figure 1: Phases of Matter Brainstorming Pages

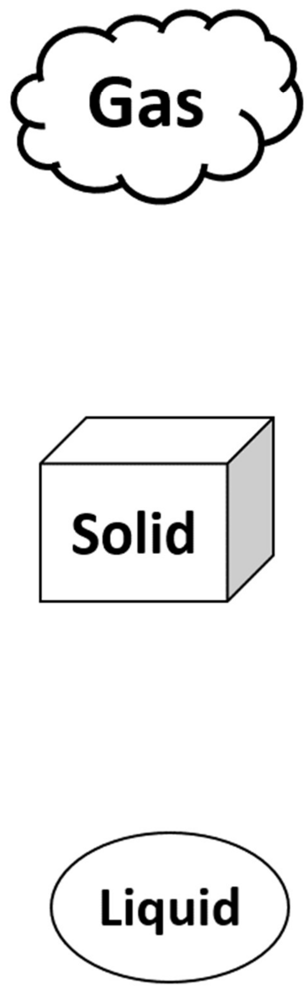
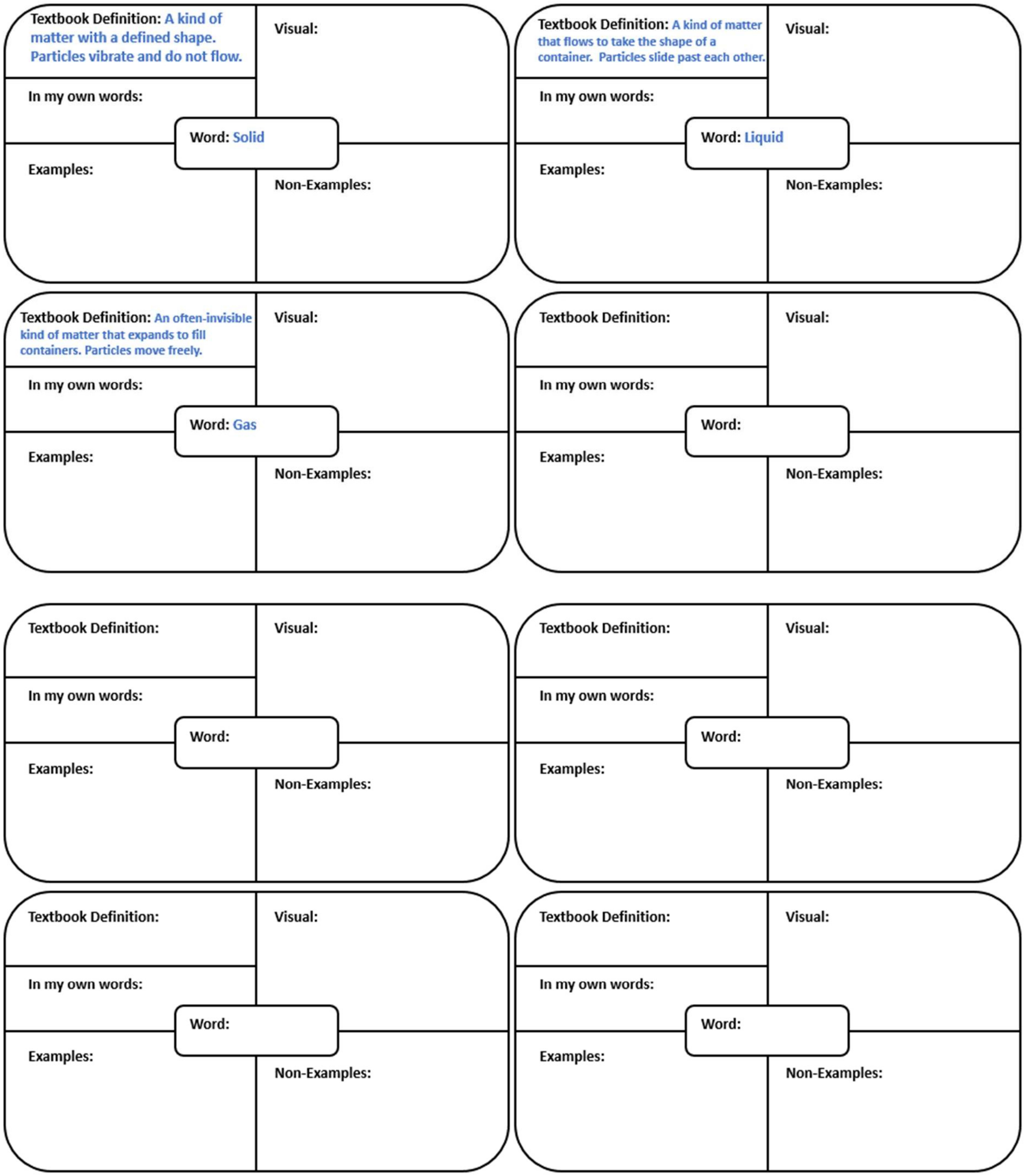


Figure 2: Frayer Models



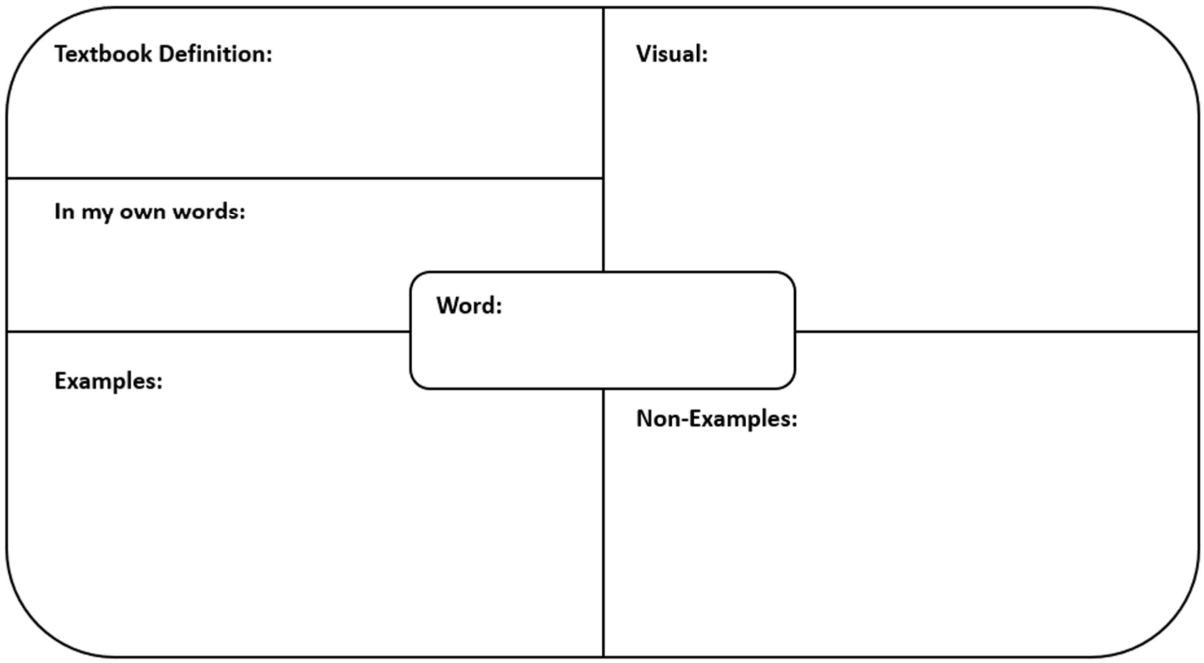
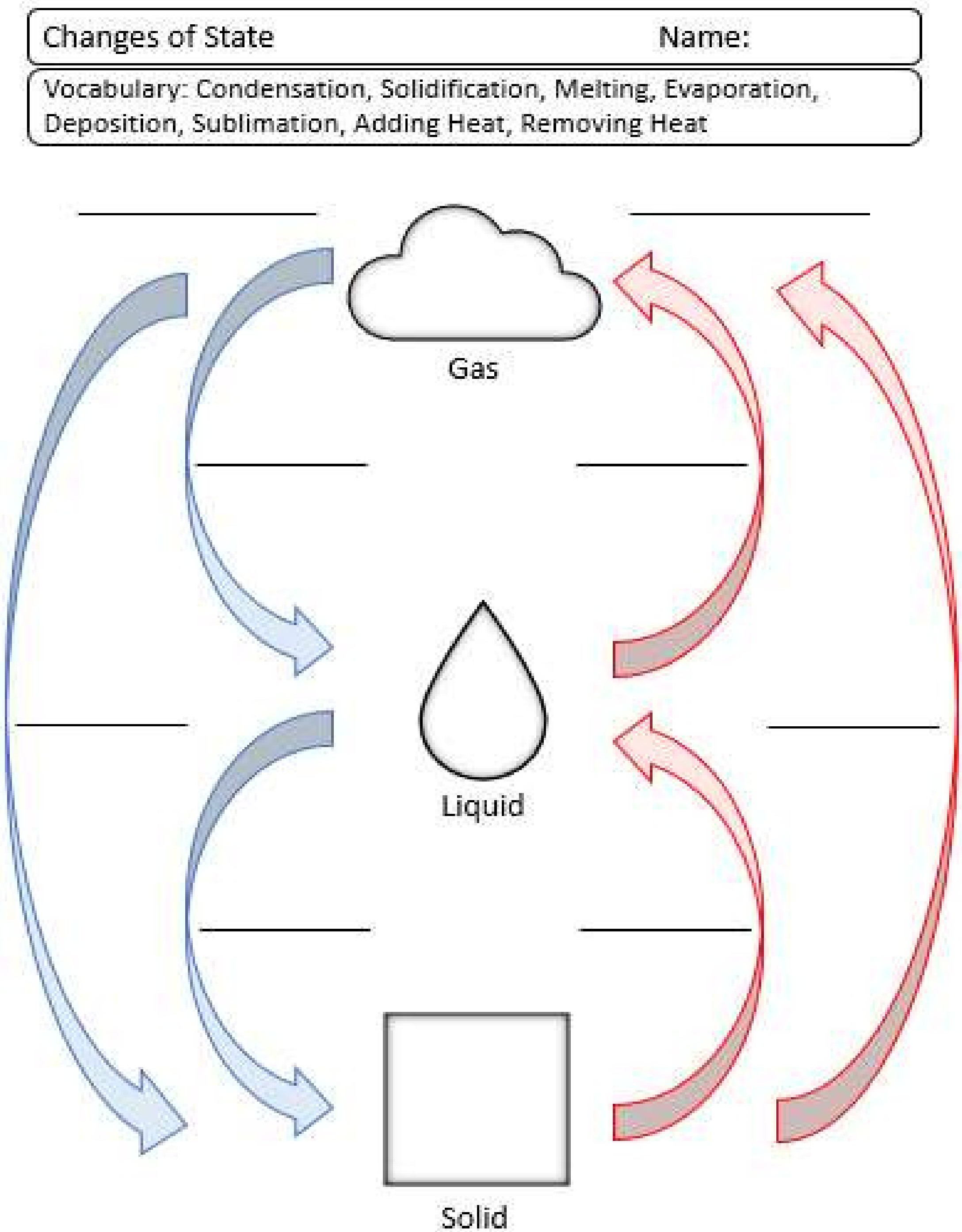

Textbook Definition:
Visual:
In my own words:
Word:
Examples:
Non-Examples:

Figure 3: Graphic Organiser for Changes of State



Lesson Two- States of Matter

BC Curriculum Content: The behavior of matter can be explained by the KMT.	**Unit Guiding Question:** Why does matter change state?

Lesson Goals:

- I can classify matter into the three states.
- I understand that the particles in solids, liquids and gases have different energy, movement, and spaces between particles.
- I understand that matter can change state.
- I can predict changes of state that will occur when heat is added or taken away.

Multiple means of representation:
Provide options for perception: Offer ways of customizing the display of information. Offer alternatives for auditory information. Provide options for language and symbols: Illustrate through multiple media. Provide options for comprehension: Activate or supply background knowledge. Highlight patterns, critical features, big ideas, and relationships. Guide information processing and visualization. Maximize transfer and generalization.
Multiple means of action and expression:
Provide options for physical action: Vary the methods for response and navigation. Provide options for expression and communication: Build fluencies with graduated levels of support for practice and performance.
Multiple means of engagement:
Provide options for recruiting Interest: Optimize relevance, value, and authenticity. Provide options for sustaining effort and persistence: Foster collaboration and community.

Processing Tasks →				
I need to… *Observe a change of state* Access	I must… *Predict a change of state* All	I can … *Explain a change of state* Most	I could… *Predict, observe, and explain multiple changes of state* Few	I can try to… *Predict, observe, and explain sublimation, deposition, recombination, and ionization* Challenge

Lesson Rationale

In this lesson, students connect their understanding that heat causes changes of state with particle models. Students build on concepts of the three states from last class. Students may know that heat causes ice to melt but here they extend that knowledge to understand that heat increases particle movement which causes ice to melt. All resources are attached to this lesson plan and available as fillable documents in Appendix B.

Student Goal Setting

Have student's check-in and show them the processing tasks for today. Remind students to try their best which is different for everyone. Have students think about how last class went and have them set a goal for today. The teacher can also check in with specific students if appropriate.

Assessing/Activating Prior Knowledge

Have students complete the entrance slip (Figure 4) to sort types of matter and definitions into a state of matter. Students should work in groups and classify as many as they can. The items to be sorted range in difficulty. Have students take out and review their Changes of State graphic organizer from last day in preparation for the next activity.

Observing and Predicting Changes of State

- This can be done as a lab in stations where students have materials (ice, hot plate etc.) as a demo by the teacher or as an interactive activity at https://interactives.ck12.org/simulations/chemistry/phases-of-matter/app/index.html?screen=sandbox.

- Have students fill out the predictions in the Predict-Observe-Explain graphic organizer (Figure 5). Then have them observe/do the activity (adding heat to solid ice). The predict and observe aspects of this activity are straight forward but the explanation involves an understanding of the KMT. Focus on having students complete the predict and observe on their own but scaffold the explanation section of the worksheet, especially if this their first experience with this format. Students can try on their own, then share with a partner then go over it with the whole group. The explanation would include that heat increases particle movement and space between particles which causes a change of state.
- Continue with other changes of state using demos, stations, videos (see https://www.youtube.com/watch?v=_GuKT6F9u2A) or the interactive activity https://interactives.ck12.org/simulations/chemistry/phases-of-matter/app/index.html?screen=sandbox. There are many videos available see: sublimation- https://www.youtube.com/watch?v=jX9pskbKSw0 or https://www.youtube.com/watch?v=7yAH0RbYhEY, deposition/sublimation- https://www.youtube.com/watch?v=sDeCg6FNuPg.
- Challenge any students who have mastery over the activity to learn about plasma and changes of state associated with it. See https://www.youtube.com/watch?v=AVEGJZxglIg and https://www.youtube.com/watch?v=YV8TT9LRBrY or http://www.chem4kids.com/files/matter_changes2.html.
- Review as a class. The key point is that adding heat causes particles to increase movement which causes a change of state from solid to liquid and from liquid to gas. It is a good time to review and build familiarity with the terminology kinetic molecular theory, reminding students that the theory is about the movement of molecules (particles).

Student Reflection

Have students reflect on how they did today. What did they do well? Did they achieve their goal? What could they change for next time? This could be a good time to check-in with students who are having difficulties to help them with goal setting and to build relationships. The focus of this is to develop a growth mindset in students and teachers; effort can increase performance and help achieve goal.

Assessment of Learning

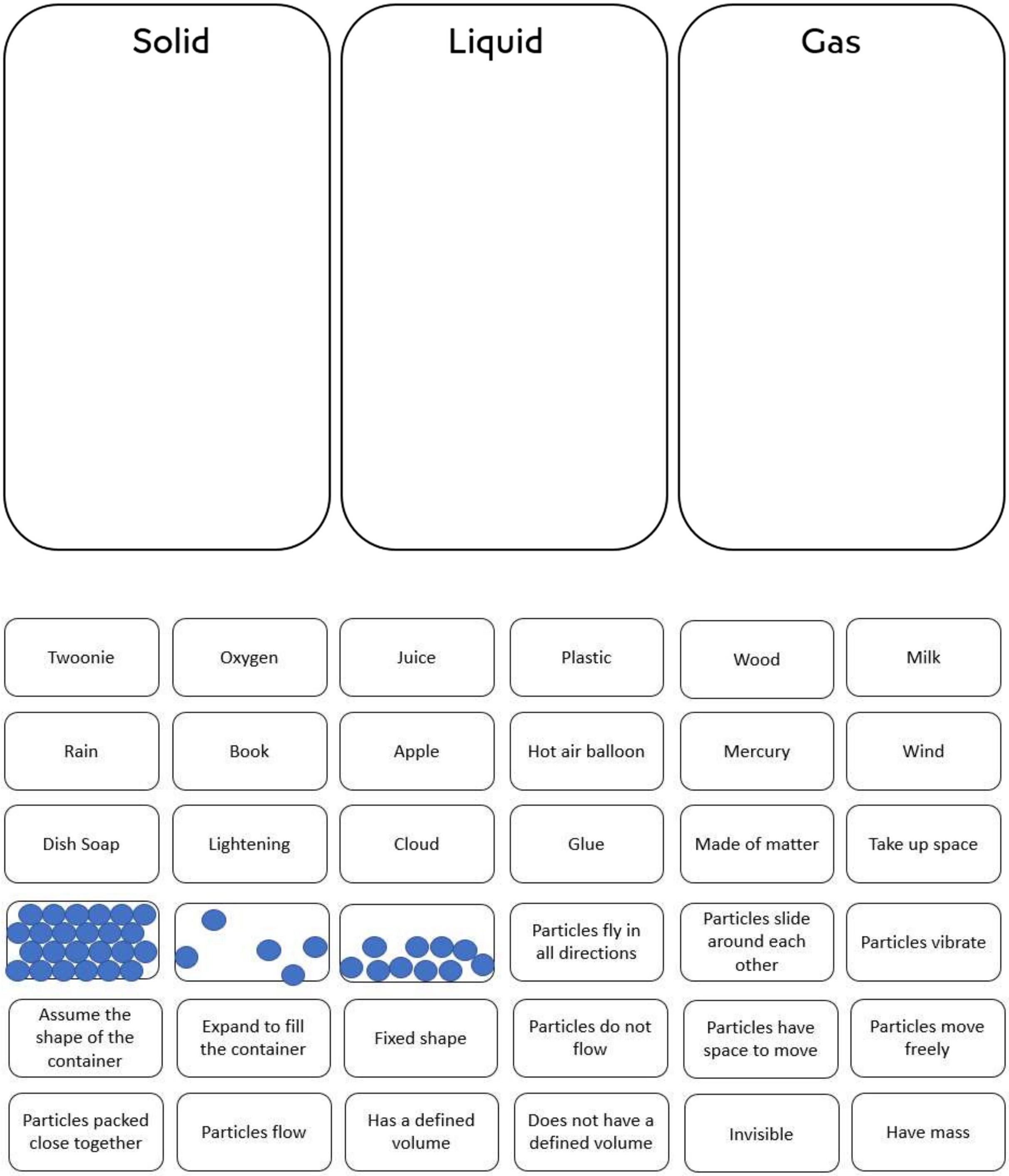
At the end of the class have students complete and hand in the associated exit slip (Figure 6) Clarify any misconceptions before students leave and/or at the beginning of next class.

Teacher Reflection

- What? What did you use? Did you change, add, or remove anything to the lesson?
- So what? Do you feel the resources helped foster inclusion, increased motivation, allowed for many students to participate and learn?
- Now what? What would you do differently next time? Are there any aspects of the lesson you will continue to use?

Lesson Two Resources

Figure 4: Entrance Slip Sorting Matter



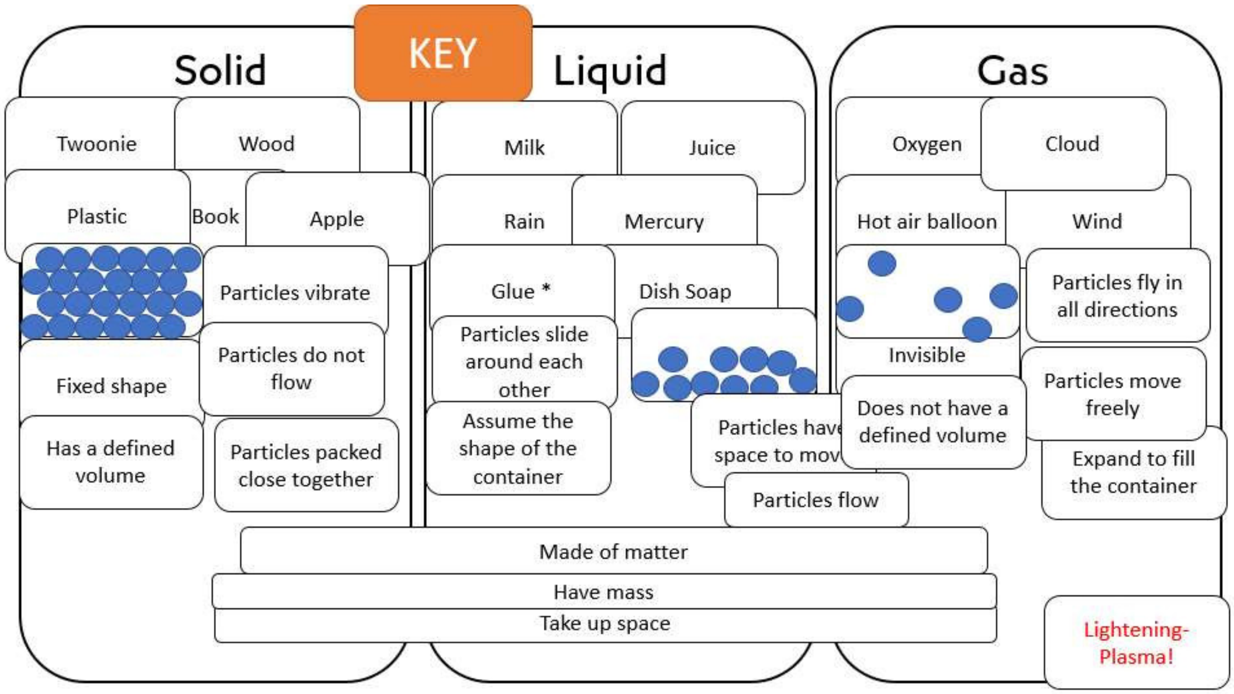
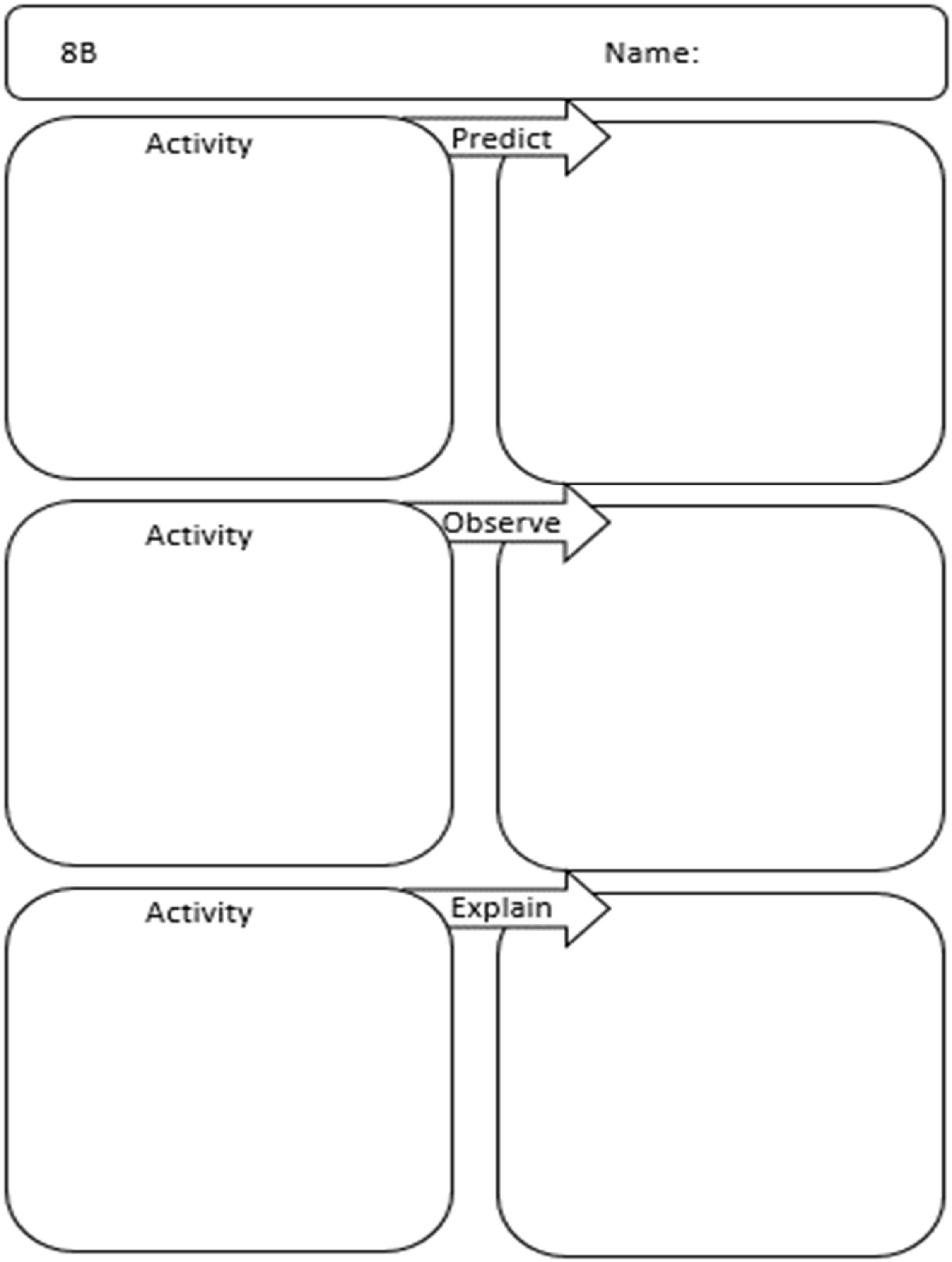

KEY
Solid
Liquid
Gas
Twoonie
Wood
Plastic
Book
Apple
Particles vibrate
Fixed shape
Particles do not flow
Has a defined volume
Particles packed close together
Milk
Juice
Rain
Mercury
Glue *
Dish Soap
Particles slide around each other
Assume the shape of the container
Particles have space to mov
Particles flow
Oxygen
Cloud
Hot air balloon
Wind
Particles fly in all directions
Invisible
Does not have a defined volume
Particles move freely
Expand to fill the container
Made of matter
Have mass
Take up space
Lightening-Plasma!

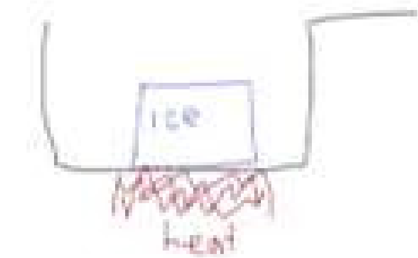
Figure 5: Predict-Observe-Explain Graphic Organizer



Example

Name: Answer Key

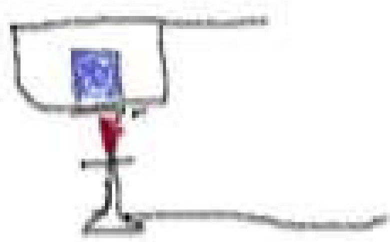
Activity



Predict

The ice will melt

Activity



Observe

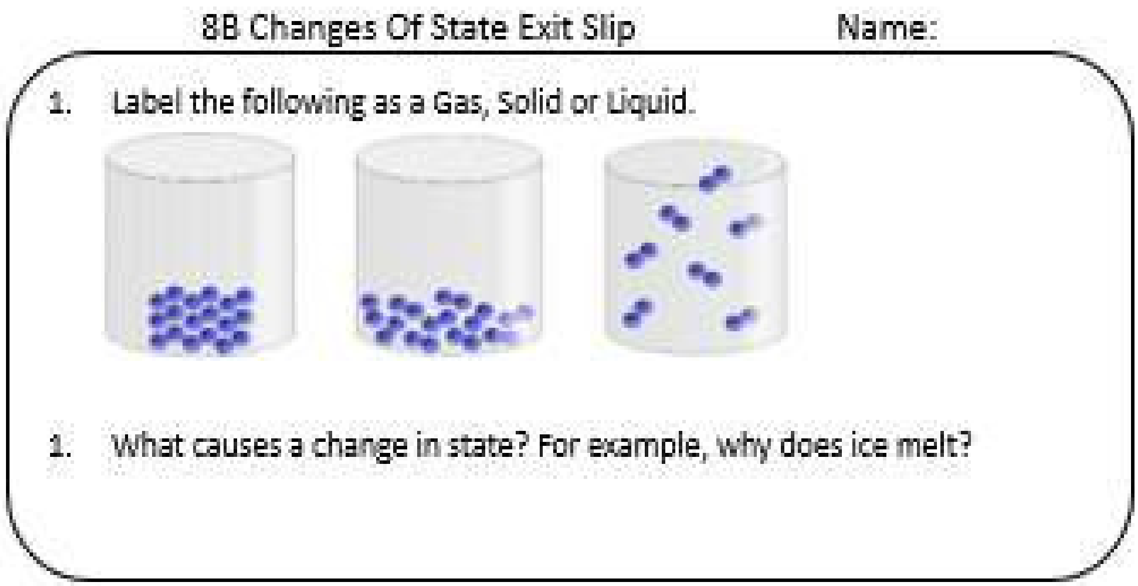
The ice is being heated in a pan

Activity

Explain

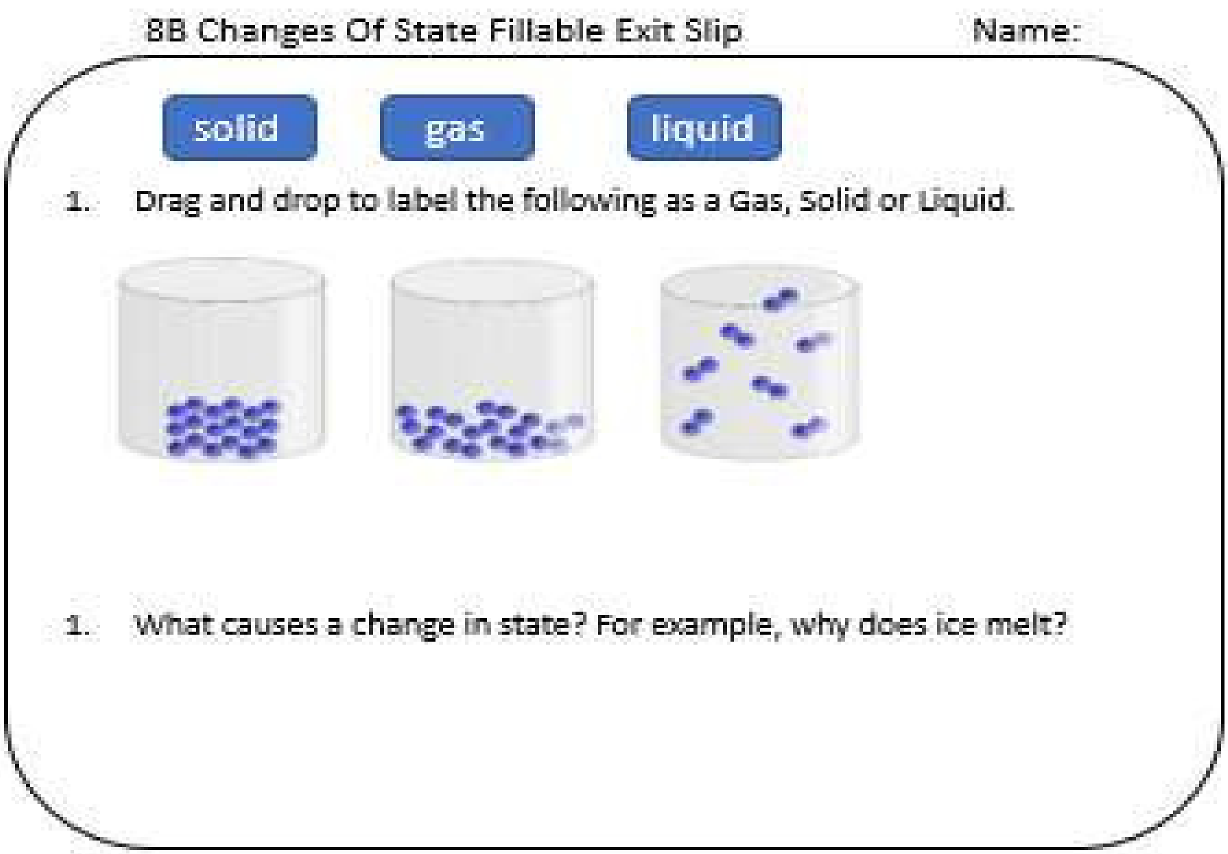
The particles in the ice moved faster, increasing the space between particles

Figure 6: States of Matter Exit Slip


8B Changes Of State Exit Slip Name:

1. Label the following as a Gas, Solid or Liquid.

1. What causes a change in state? For example, why does ice melt?


8B Changes Of State Fillable Exit Slip Name:

solid gas liquid

1. Drag and drop to label the following as a Gas, Solid or Liquid.

1. What causes a change in state? For example, why does ice melt?

Answer Key

8B Changes Of State Exit Slip Name:

1. Label the following as a Gas, Solid or Liquid.

1. What causes a change in state? For example, why does ice melt?

Changing the temperature, changes the movement of particles causing a change in state. Heating a solid causes particles to move and the solid will melt and become a liquid.

Lesson Three - KMT

BC Curriculum Content: The behavior of matter can be explained by the KMT.	**Unit Guiding Question: Why** does matter change state?

Lesson Goal:

- I understand that the particles in solids, liquids and gases have different energy, movement, and spaces between particles.
- I understand that changes in energy (heat) cause changes in particle movement which causes a change of state.

UDL Checkpoints

Multiple means of representation:

Provide options for perception: Offer ways of customizing the display of information. Offer alternatives for auditory information. Provide options for language and symbols: Clarify vocabulary. Illustrate through multiple media. Provide options for comprehension: Activate or supply background knowledge. Highlight patterns, critical features, big ideas, and relationships. Guide information processing and visualization. Maximize transfer and generalization.

Multiple means of action and expression:

Provide options for physical action: Optimize access to tools and assistive technologies. Provide options for expression and communication: Use multiple media for communication. Use multiple tools for construction and composition. Build fluencies with graduated levels of support for practice and performance.

Multiple means of engagement:

Provide options for recruiting interest: Optimize relevance, value, and authenticity. Provide options for sustaining effort and persistence: Vary demands and resources to optimize challenge.

Processing Tasks →				
I need to… *Observe a change of state using a computer simulation* Access	I must… *Complete the first page of the worksheet* All	I can … *Complete questions 4 and 5* Most	I could… *Complete all the questions on the worksheet* Few	I can try to… *Understand the phase diagram in the simulation* Challenge

Lesson Rationale

In this lesson, students use an online simulator to explore ideas about how particles cause changes of state. This is an extension from last class and helps students build familiarity with the particle model of matter and the KMT. KMT is a daunting vocabulary word but as students use a simulator, they can observe the particles motion speeding up and the space between particles increasing as they add heat. This experience should help increase their understanding that as heat is added particles movement increases and state changes (from solid to liquid to gas) conversely as heat is removed particles movement decreases and state changes (from gas, to liquid to solid). The simulator is a novel way for students to ‘observe’ representations of the invisible particles within matter. All resources are attached to this lesson plan and available as fillable documents in Appendix C.

Intro Activity

Use an anchor video to review concepts of the particle theory of matter such as one from Crash Course Kids - PBS Learning https://www.youtube.com/watch?v=npv74DMO6Q.

Student Goal Setting

Have students check-in and show them the processing tasks for today. Remind students to try their best which is different for everyone. Have students think about how last class went and have them set a goal for today.

KMT Interactive Activity

- Using the simulation such as the one available from the University of Colorado website at: http://phet.colorado.edu/sims/html/states-of-matter/latest/states-of-matter_en.html. Have students explore changes of state and fill out the States of Matter Simulation worksheet (Figure 7). The first page of the worksheet is designed to be accessible and includes the main idea of the lesson. Review the activity with students. The key idea is that that increasing/decreasing heat increases/decreases the movement of particles and causes a change in state.
- To challenge students interested in the phase diagram on the simulator site you can direct them to PBS Digital Studios https://www.youtube.com/watch?v=WOEvvHbC40 .
- Check that student have filled out the worksheet and check for understanding as you circulate the room during the activity. Review the worksheet as a class. It would be a good time to review the terminology KMT as it pertains to their recent experience. All students should have some understanding that the movement of particles is associated with a change of state.

Assessment of Learning

Use the States of Matter Simulation Review Presentation (Figure 8) and response cards (Figure 9) to check students understanding. Students each have a 'response card', this doesn't have to be the attached cards, it could be a mini whiteboard or chalkboard where they can write their response, a laminated card or a physical response (A/B/C/D in sign language, point to different corners of the room etc.). The important element is that each student is encouraged to answer every question in the presentation. Using a response card type assessment of learning can increase motivation and engagement. It is also a quick way for the teacher to assess students understanding.

Student Reflection

Have students reflect on how they did today. What did they do well? Did they achieve their goal? What could they change for next time? This could be a good time to check-in with students who are having difficulties to help them with goal setting and to build relationships. The focus of this is to develop a growth mindset in students and teachers; effort can increase performance and help achieve goal.

Teacher Reflection

- What? What did you use? Did you change, add, or remove anything to the lesson?
- So what? Do you feel the resources helped foster inclusion? Increased motivation, allowed for many students to participate and learn?
- Now what? What would you do differently next time? Are there any aspects of the lesson you will continue to use?

Lesson Three Resources

Figure 7: States of Matter Simulation Worksheet

8C States of Matter Simulation Name:

Go to the States of Matter simulation at: https://phet.colorado.edu/sims/html/states-of-matter-basics/latest/states-of-matter-basics_en.html

1. Click on the Solid icon 

and draw the particles.

a. How are the particles moving? Circle one.

vibrating / sliding past each other/ moving freely

b. How much space is between particles?

well separated/ close together / tightly packed

2. Click on the Liquid icon 

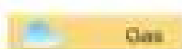
and draw the particles.

a. How are the particles moving?

vibrating / sliding past each other/ moving freely

b. How much space is between particles?

well separated/ close together / tightly packed

3. Click on the Gas icon 

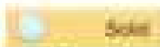
and draw the particles.

a. How are the particles moving?

vibrating / sliding past each other/ moving freely

b. How much space is between particles?

well separated/ close together / tightly packed

4. Click on the Solid icon  . Heat in the container. What happens to the particles?

____

____

a. What do you think is happening to state of the matter as you add heat?

____

____

b. Now Cool the container? What happens to the particles?

____

____

c. What do you think is happening to the state of matter as you remove heat (or cool it)?

____

____

5. Using observations from this simulation, why does matter change state?

____

____

6. What do you notice about the simulation when you run it with different atoms and molecules? 

____

____

____

____

7. Open the 'Phase Changes' simulation.  What happens when you increase or decrease pressure? Phase Changes

____

____

____

____

8. What happens when you decrease or increase the volume of the container?

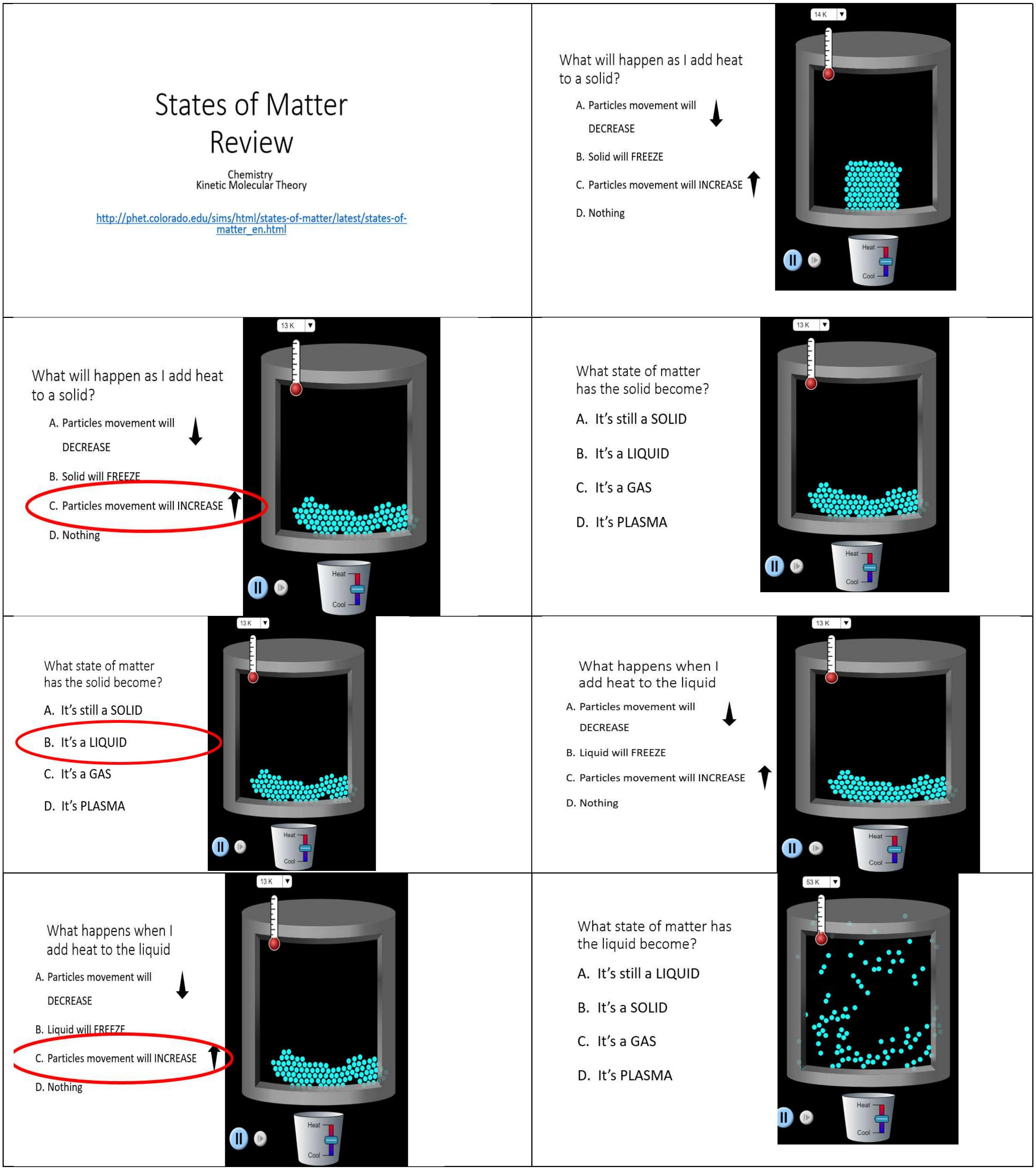
____

____

____

____

Figure 8: States of Matter Simulation Review Presentation



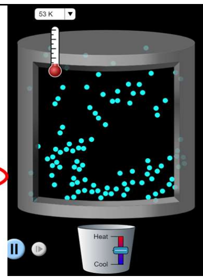
What state of matter has the liquid become?

A. It's still a LIQUID

B. It's a SOLID

C. It's a GAS

D. It's PLASMA



Increasing heat…

A. INCREASES particle movement

B. DECREASES particle movement

Increasing heat…

A. INCREASES particle movement

B. DECREASES particle movement

Increased particle movement causes…

A. Nothing

B. A change in state

Increased particle movement causes…

A. Nothing

B. A change in state

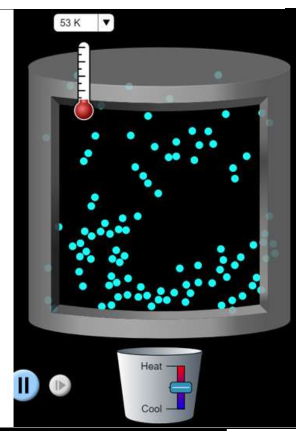
What happens when I cool the gas

A. Particles movement will DECREASE ↓

B. Liquid will FREEZE

C. Particles movement will INCREASE ↑

D. Nothing



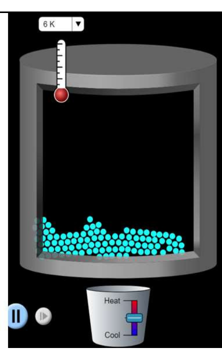
What happens when I cool the gas

A. Particles movement will DECREASE ↓

B. Liquid will FREEZE

C. Particles movement will INCREASE ↑

D. Nothing



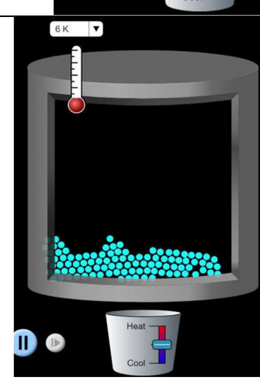
What state of matter has the gas turned into?

A. It's still a GAS

B. It's a SOLID

C. It's a LIQUID

D. It's PLASMA



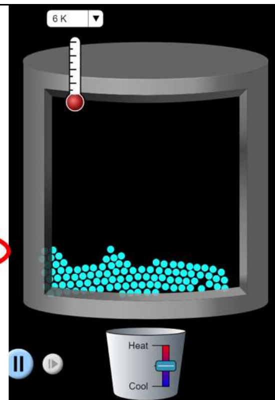
What state of matter has the gas turned into?

A. It's still a GAS

B. It's a SOLID

C. It's a LIQUID

D. It's PLASMA



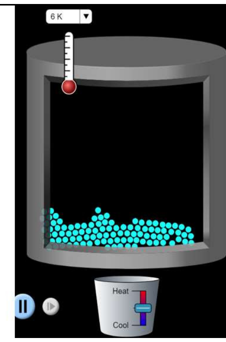
What happens when I cool the liquid

A. Particles movement will DECREASE

B. Liquid will FREEZE

C. Particles movement will INCREASE

D. Nothing



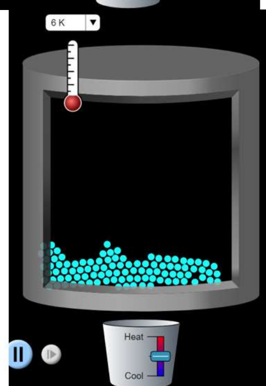
What happens when I cool the liquid

A. Particles movement will DECREASE

B. Liquid will FREEZE

C. Particles movement will INCREASE

D. Nothing



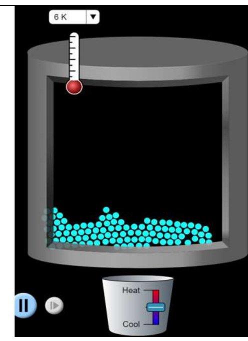
What state of matter has the liquid become?

A. It's still a LIQUID

B. It's a SOLID

C. It's a GAS

D. It's PLASMA



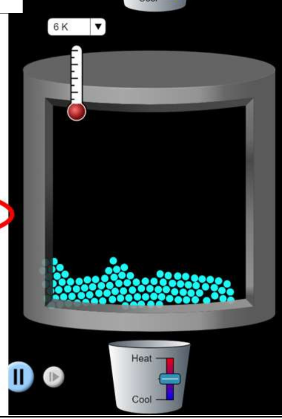
What state of matter has the liquid become?

A. It's still a LIQUID

B. It's a SOLID

C. It's a GAS

D. It's PLASMA



Cooling or decreasing heat…

A. INCREASES particle movement

B. DECREASES particle movement

Cooling or decreasing heat …

A. INCREASES particle movement

B. DECREASES particle movement

Decreased particle movement causes…

A. Nothing

B. A change in state

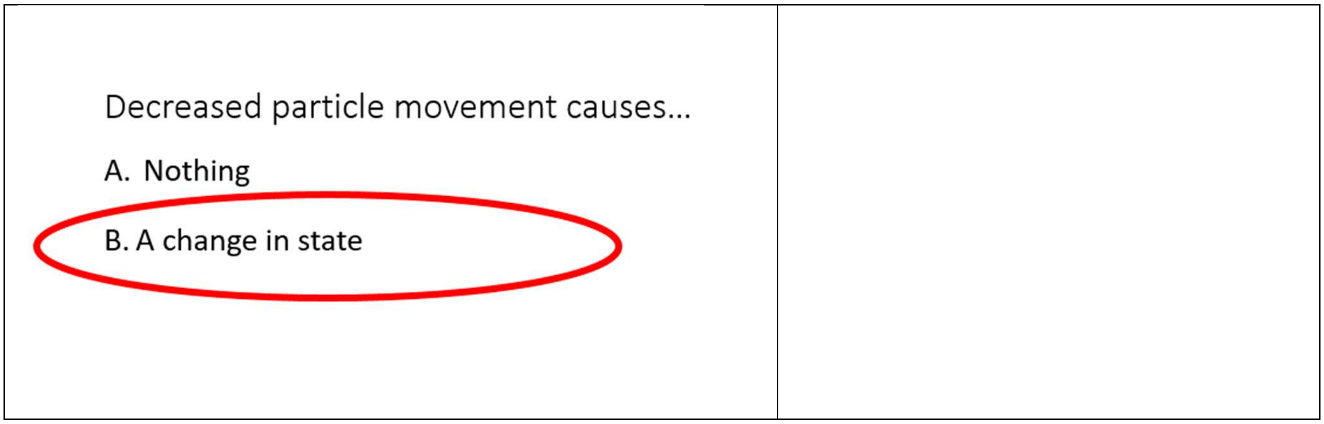
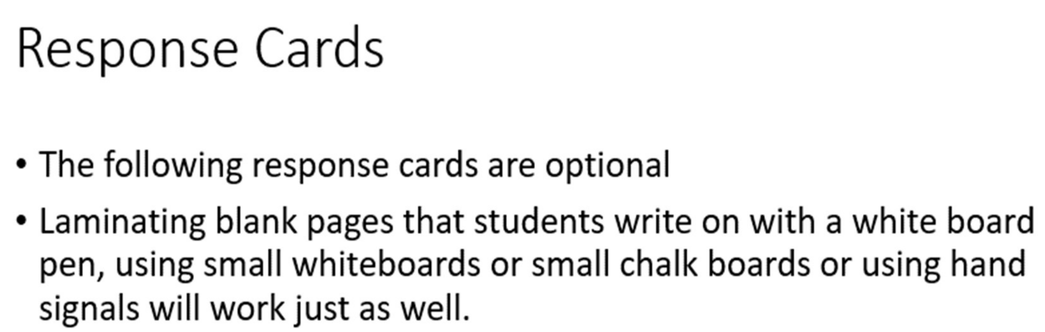


Figure 9: Response Cards



A B

C D

Lesson Four - Models of the Atom

BC Curriculum Content: The behavior of matter can be explained by KMT and Atomic Theory	**Unit Guiding Question**: How do particles explain an element's properties?

Lesson Goals:

- I understand atoms are the smallest part of an element that retains properties of the element.
- I understand atoms are made of smaller particles.
- I can represent the parts of an atom according to atomic theory (protons, neutrons, and electrons).
- I can identify models of the atom.

UDL Checkpoints

Multiple means of representation:

Provide options for perception: Offer ways of customizing the display of information. Offer alternatives for auditory information. Offer alternatives for visual information. Provide options for language and symbols: Clarify vocabulary and symbols. Provide options for comprehension: Activate or supply background knowledge. Highlight patterns, critical features, big ideas, and relationships.

Multiple means of action and expression:

Provide options for physical action: Vary the methods for response and navigation. Provide options for expression and communication: Use multiple media for communication. Use multiple tools for construction and composition.

Multiple means of engagement:

Provide options for recruiting Interest: Optimize individual choice and autonomy. Optimize relevance, value, and authenticity. Provide options for sustaining effort and persistence: Foster collaboration and community.

Processing Tasks →				
I need to… *Understand that ideas of the atom have changed over time* Access	I must… *Create a model of the atom* All	I can … *Find five facts about my model* Most	I could… *Describe how my model is accurate and how it is inaccurate* Few	I can try to… *Find strengths for each historical model* Challenge

Lesson Rationale

This lesson extends students understanding of particles that make up matter to include subatomic particles. We look within particles of matter at subatomic particles whereas the previous lessons have looked only at particles (molecules) that make up matter. Prior knowledge on matter and subatomic particles will be accessed and built upon as students learn about how our understanding of the parts of matter has changed over time. Students will work collaboratively with others to create a model. This lesson gives the opportunity for student choice in how they show their understanding as well as some choice in what they learn about. Key vocabulary: atom, element, molecule, model, proton, neutron, electron, nucleus.

Accessing Prior Knowledge

Brainstorming- Have students brainstorm about 'What is matter made of?" on a sheet of paper. Review ideas as a class. This is an opportunity to build on the ideas from previous lessons that matter is made of particles. We know that heating the atoms causes changes in state, now we will learn that changing what is inside the atoms will change the properties of matter itself.

Student Goal Setting

Have students check-in and show them the processing tasks for today. Remind students to try their best which is different for everyone. Have students think about how last class went and have them set a goal for today. The teacher can also check in with specific students if appropriate.

Building on Knowledge

Use the video (https://www.youtube.com/watch?v=xazQRcSCRaY&t=220s) as an anchor activity to review and build some knowledge about matter, subatomic particles and how understanding has changed over time. This helps to build knowledge about the models students will be asked to make. It can be helpful to clarify the word 'subatomic' for students. It seems like a daunting word but just means smaller than or inside an atom.

Expert Activity

- This is a group activity where students work in small groups to learn about a model of the atom, then present their findings and 'teach' others about their model. There is an opportunity for teachers to provide student choice in how they work (in a group, alone, student chosen partners etc.), how they learn and how they will represent their learning. Students may need support working in a group. The teacher can help groups assign roles/ divide work and set goals for the class. Use the Atomic Model Expert Activity assignment sheets (Figure 10) to help students complete the activity.
- Have students collect information about their chosen model and then make a representation of what they learned. Teacher could provide or have students bring a variety of materials/resources such as: computers, crafting materials (pipe cleaners, noodles, modeling clay or dough etc.) and art supplies. These materials can give students more options as to their representation of the model.
- Have a gallery walk or pair individuals up from different groups so that they can act as 'experts' on their model and explain it to others. Teacher can circulate to see how students understand the various models.
- Review models as a class. If time show one of the videos that recaps all the models (see the model handouts). This activity could span more than one class depending on student strengths and teacher expectations.

Student Reflection

Have students reflect on how they did today. What did they do well? Did they achieve their goal? What could they change for next time? Check-in with students who are having difficulties to help them with goal setting and to build relationships. The focus of this is to develop a growth mindset in students and teachers; effort can increase performance and help achieve goal.

Assessment of Learning

Have students complete the exit slip (Figure 11). Clarify any misconceptions before students leave and/or at the beginning of next class.

Teacher Reflection

- What? What did you use? Did you change, add, or remove anything to the lesson?
- So what? Do you feel the resources helped foster inclusion? Increased motivation, allowed for many students to participate and learn?
- Now what? What would you do differently next time? Are there any aspects of the lesson you will continue to use?

Lesson Four Resources

Figure 10: Atomic Model Expert Activity

Dalton's Model of the Atom Name:

Please gather information about the model of the atom. You could use: page ____ in the textbook, online videos https://www.youtube.com/watch?v=sG6QoLxwIw4, https://www.youtube.com/watch?v=xazQRcSCRaY&t=54s or online readings https://thehistoryoftheatomicmodel.weebly.com/the-solid-sphere-model.html, https://www.siyavula.com/read/science/grade-10/the-atom/04-the-atom-02 , https://brilliant.org/wiki/daltons-atomic-model/.

Picture of the model:

Notes:

What materials do you need?

Thompson's Model of the Atom Name:

Please gather information about the model of the atom. You could use: page ____ in the textbook, online videos https://www.youtube.com/watch?v=sG6QoLxwIw4, https://www.youtube.com/watch?v=xazQRcSCRaY&t=54s , https://www.youtube.com/watch?v=JUJPyQtoB5E, https://www.youtube.com/watch?v=2xKZRpAsWL8 or online readings https://thehistoryoftheatomicmodel.weebly.com/plum-pudding-model.html, https://www.siyavula.com/read/science/grade-10/the-atom/04-the-atom-02

Picture of the model:

Notes:

What materials do you need?

Rutherford's Model of the Atom Name:

Please gather information about the model of the atom. You could use: page ____ in the textbook, online videos https://www.youtube.com/watch?v=sG6QoLxwIw4 , https://www.youtube.com/watch?v=1StzvGFX4_c (0 to 2 minutes)
https://www.youtube.com/watch?v=xazQRcSCRaY&t=54s, https://www.youtube.com/watch?v=B-k_lkMwB1zM, https://www.youtube.com/watch?v=Y6-pAP6CIfw or online readings https://thehistoryoftheatomicmodel.weebly.com/nuclear-model.html. https://www.siyavula.com/read/science/grade-10/the-atom/04-the-atom-02.

Picture of the model:

Notes:

What materials do you need?

Bohr's Model of the Atom Name:

Bohr's Atomic Model: Please gather information about the model of the atom. You could use: page ____ in the textbook, online videos https://www.youtube.com/watch?v=sG6QoLxwIw4 , https://www.youtube.com/watch?v=1StzvGFX4_c (from 2- 3minutes) https://www.youtube.com/watch?v=xazQRcSCRaY&t=54s, https://www.youtube.com/watch?v=fm2C0ovz-3M or online readings https://thehistoryoftheatomicmodel.weebly.com/solar-system-model.html, https://www.siyavula.com/read/science/grade-10/the-atom/04-the-atom-02.

Picture of the model:

Notes:

What materials do you need?

Electron Cloud Model of the Atom Name:

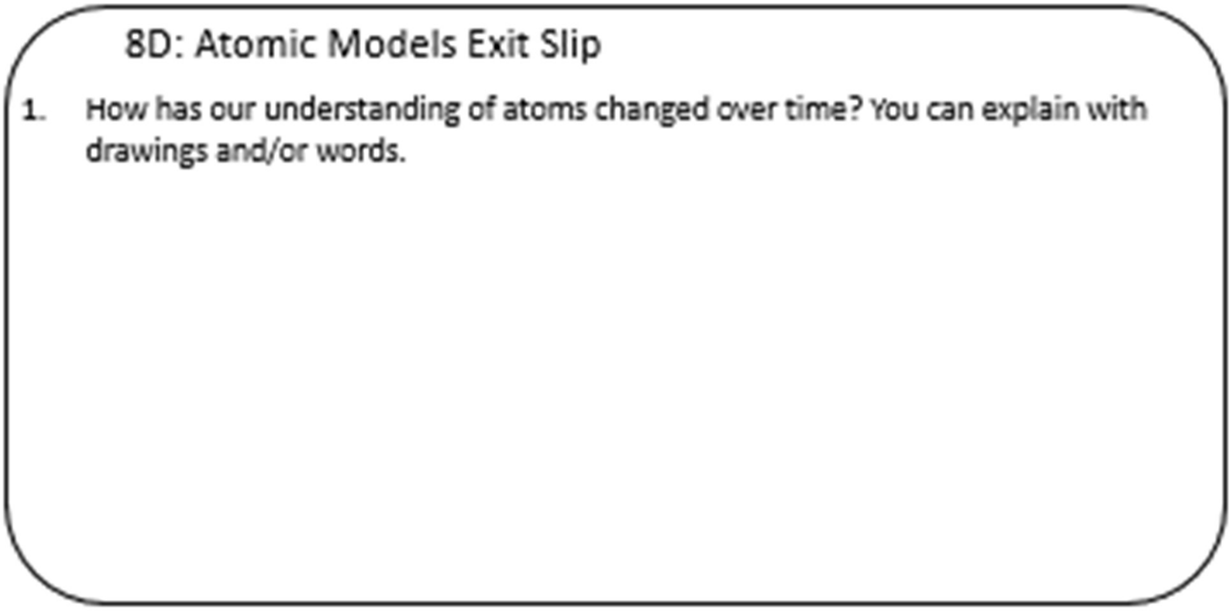
Electron Cloud Atomic Model: Please gather information about the model of the atom. You could use: page ____ in the textbook, online videos https://www.youtube.com/watch?v=FMlZq9NG_lo or (around 4 minutes) https://www.youtube.com/watch?v=rcKilE9CdaA or https://www.youtube.com/watch?v=1StzvGFX4_c&t=191s or online readings https://www.ck12.org/c/physical-science/electron-cloud-atomic-model/lesson/Electron-Cloud-Atomic-Model-MS-PS/ or https://thehistoryoftheatomicmodel.weebly.com/electron-cloud-model.html

Picture of the model:

Notes:

What materials do you need?

Figure 11: Models of the Atom Exit Slip



8D: Atomic Models Exit Slip

1. How has our understanding of atoms changed over time? You can explain with drawings and/or words.

Lesson Five - Atomic Theory

BC Curriculum Content: The behavior of matter can be explained by KMT and Atomic Theory	**Unit Guiding Question:** How do particles explain an element's properties?

Lesson Goals:
- I can represent an atom.
- I understand that atomic structure effects the behaviour of matter. For example, I understand that proton number defines the element, neutrons are associated with mass and electrons with charge.

UDL Checkpoints
Multiple means of representation:
Provide options for perception: Offer ways of customizing the display of information. Offer alternatives for auditory information. Provide options for language and symbols: Clarify vocabulary and symbols. Illustrate through multiple media. Provide options for comprehension. Activate or supply background knowledge. Highlight patterns, critical features, big ideas, and relationships. Guide information processing and visualization.
Multiple means of action and expression:
Provide options for physical action: Vary the methods for response and navigation. Optimize access to tools and assistive technologies. Provide options for expression and communication. Use multiple media for communication. Use multiple tools for construction and composition.
Multiple means of engagement:
Provide options for recruiting interest: Optimize individual choice and autonomy. Optimize relevance, value, and authenticity. Provide options for sustaining effort and persistence. Heighten salience of goals and objectives. Vary demands and resources to optimize challenge.

Processing Tasks →				
I need to… *Use the simulator to build atoms* Access	I must… *Complete the first page of the worksheet* All	I can … *Complete question 5* Most	I could… *Complete an 'adventure' activity* Few	I can try to… *Complete multiple 'adventure' activities* Challenge

Lesson Rationale

This lesson reviews and builds knowledge of atomic structure. Students use a simulator to build atoms, discovering that properties (and even the element) change when particles are added or removed. The simulator helps students play with atoms to get a better understanding of subatomic particles and what they do. To increase engagement students can complete a 'choose your own adventure' style activity which encourages to choose related topics that they are curious about. All resources are attached to this lesson plan and available as fillable documents in Appendix E.

Activating Knowledge

To review concepts and build knowledge have students fill out the Entrance Slip (Figure 12) for prior knowledge on atomic structure. Much of this was in videos watched in previous classes and may be a review for some students. Review the entrance slip with the class using the attached key. If knowledge is high the building knowledge section could be skipped.

Student Goal Setting

Have students check-in and show them the processing tasks for today. Remind students to try their best which can look different for everyone. Have students think about how last class went and have them set a goal for today. The teacher can also check in with specific students if appropriate.

Building knowledge

- Have students complete Frayer Model sheets (Figure 2) on: proton, electron and neutron using the textbook or online resources (for example: https://kids.kiddle.co/Atom). Students who finish quickly can also complete sheets on leptons and quarks.

- The video clip from Stated Clearly https://www.youtube.com/watch?v=ooWfzpUIoNM or Fuse School https://www.youtube.com/watch?v=pNroKeV2fgk can also be used to build this knowledge.

Multimedia/Article Activity

Using the Building an Atom interactive activity (see https://phet.colorado.edu/sims/html/build-an-atom/latest/build-an-atom_en.html) have students explore atoms and subatomic particles and fill in the associated worksheet (Figure 13). The simulator increases knowledge of structure of the atom and function of subatomic particles. The main idea is to see what happens when the number of protons/ electrons/ neutrons change. This introduces ideas around chemical properties of matter where particles determine elements properties. The back of worksheet is a ‘choose your own adventure’ style activity. Students choose topics that interest them and learn about them by either following the links or researching them on their own (or both).

Student Reflection

Have students reflect on how they did today. What did they do well? Did they achieve their goal? What could they change for next time? Check-in with students who are having difficulties to help them with goal setting and to build relationships. The focus of this is to develop a growth mindset in students and teachers; effort can increase performance and help achieve goal.

Assessment of Learning

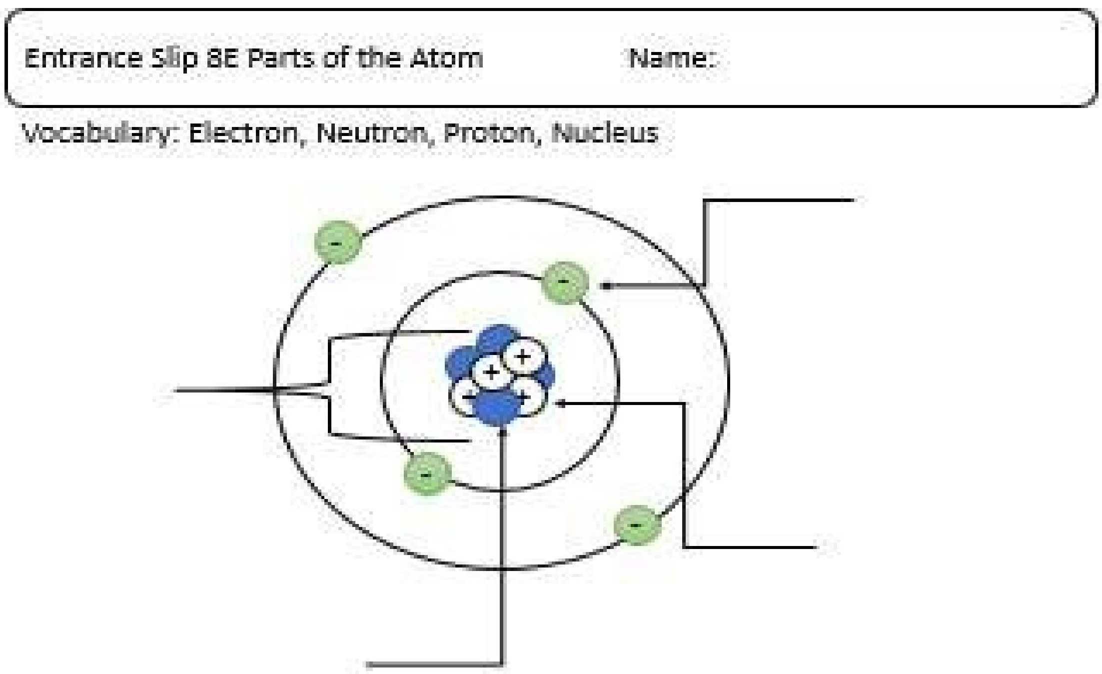
Use the exit slip (Figure 14) to check understanding on the parts of the atom. The teacher can then address any misconceptions before students leave and/or at the start of next class.

Teacher Reflection

- What? What did you use? Did you change, add, or remove anything to the lesson?
- So what? Do you feel the resources helped foster inclusion? Increased motivation, allowed for many students to participate and learn?
- Now what? What would you do differently next time? Are there any aspects of the lesson you will continue to use?

Lesson Five Resources

Figure 12: Atomic Theory Entrance Slip



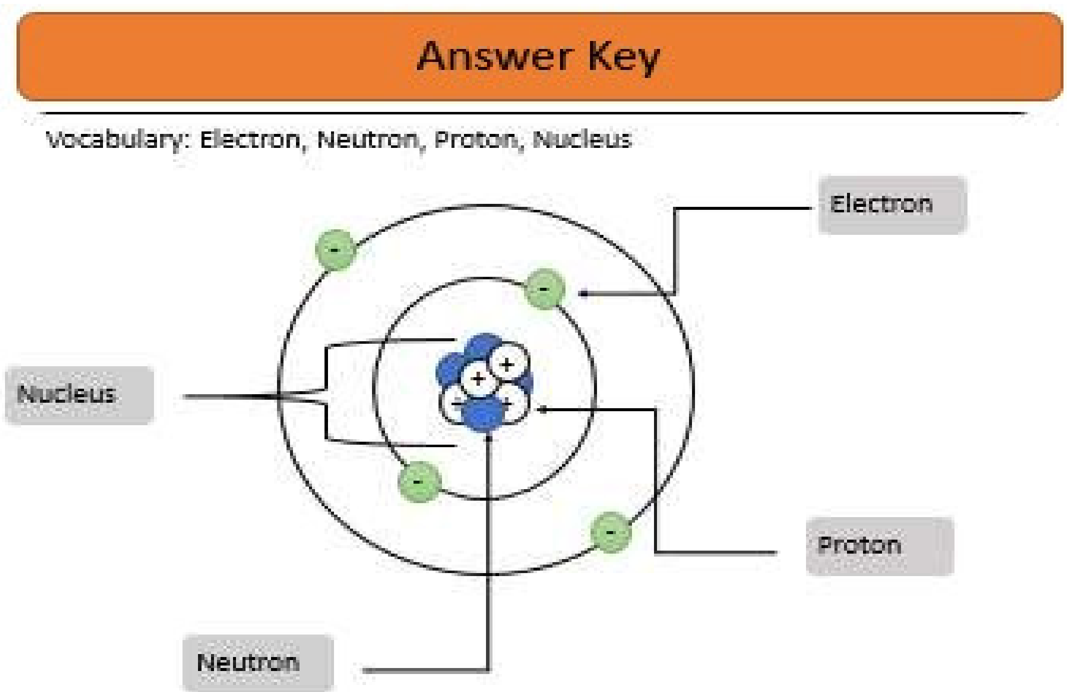


Figure 13: Building Atoms Worksheet

8E Building Atoms name:

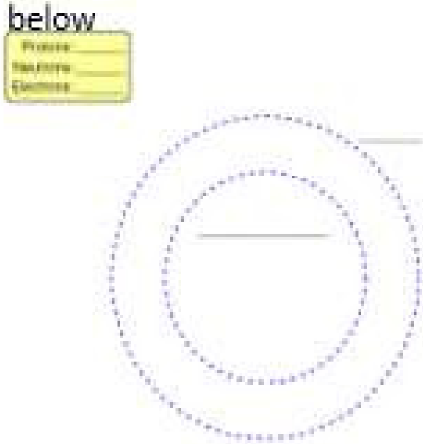
Go to the following website: https://phet.colorado.edu/sims/html/build-an-atom/latest/build-an-atom_en.html. Click on the 'Atom' icon. Open the 'Net Charge' and 'Mass Number' tabs

1. Add a proton (red) to the atom and observe what happens. Add more protons and observe what happens. What happens when you add protons to the atom? Circle ALL that apply.
   a) The element changes
   b) Mass number increases
   c) Net charge becomes positive +
   d) Net charge becomes negative -

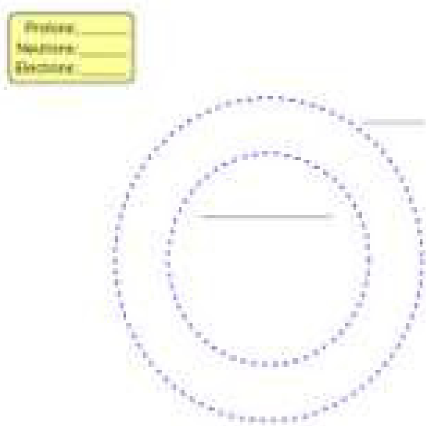
2. Add neutrons (gray) and observe what happens. What happens when you add neutrons to an atom? Circle ALL that apply.
   a) The element changes
   b) Mass number increases
   c) Net charge becomes positive +
   d) Net charge becomes negative -

3. Add electrons and observe what happens. What happens when electrons are added to an atom? Circle ALL that apply.
   a) The element changes
   b) Mass number increases
   c) Net charge becomes positive +
   d) Net charge becomes negative –

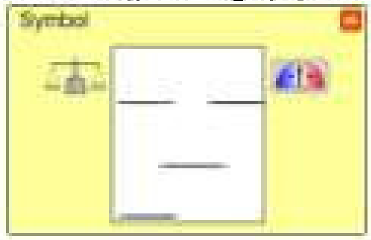
4. Build an atom and draw it below



Build a carbon atom with a net charge of +1 and a mass number of 11. Draw it below.



5. Open the 'Symbol icon'. This shows how atoms are represented on the periodic table. Label each part of the box with the following: **A.** # protons, **B.** mass number (# protons + neutrons), **C.** charge (# protons – electrons), and **D.** chemical symbol.



Choose your Own Adventure

If you would like to play a game go to A if you would like to watch some videos to learn a bit more got to B.

A. Games

1. Game 1 – Test yourself to see how much you know about building atoms. https://phet.colorado.edu/sims/html/build-an-atom/latest/build-an-atom_en.html

2. Game 2- What does the charge on the atom actually do? http://www.castl.uci.edu/games/bondbreaker

B. Choose a video on a topic that you are curious about.

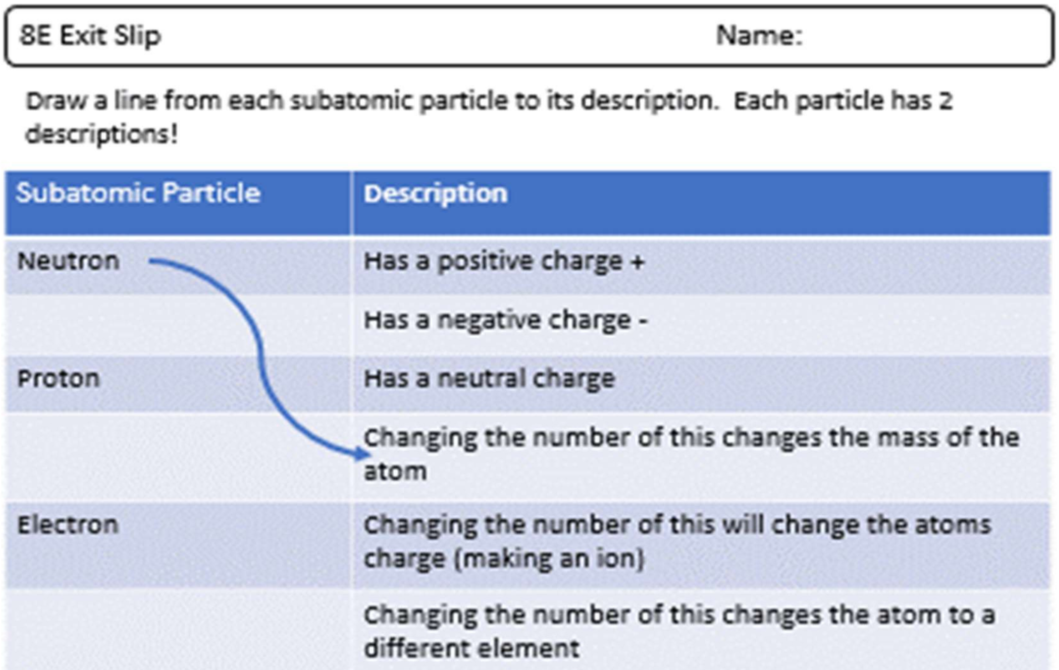
1. How big is an atom? Ted Ed- https://www.youtube.com/watch?v=yQP4UJhNn0I

2. Can we see subatomic particles in real life? BBC- https://www.youtube.com/watch?v=QJc06XG1R8M
Nova - https://www.youtube.com/watch?v=szcboZhB6Yc

3. Am I made of star stuff? PBS- https://www.youtube.com/watch?v=VnsWz4pb11s or https://www.pbslearningmedia.org/resource/ess05.sci.ess.eiu.fusion/the-elements-forged-in-stars/ or https://www.youtube.com/watch?v=6yLGeviU8FM or Ted Talk- https://www.youtube.com/watch?v=YCQPw9pbZnk

4. Where do atoms come from? Smithsonian- https://www.youtube.com/watch?v=xIV-k39Kukw

Figure 14: Atomic Theory Exit Slip

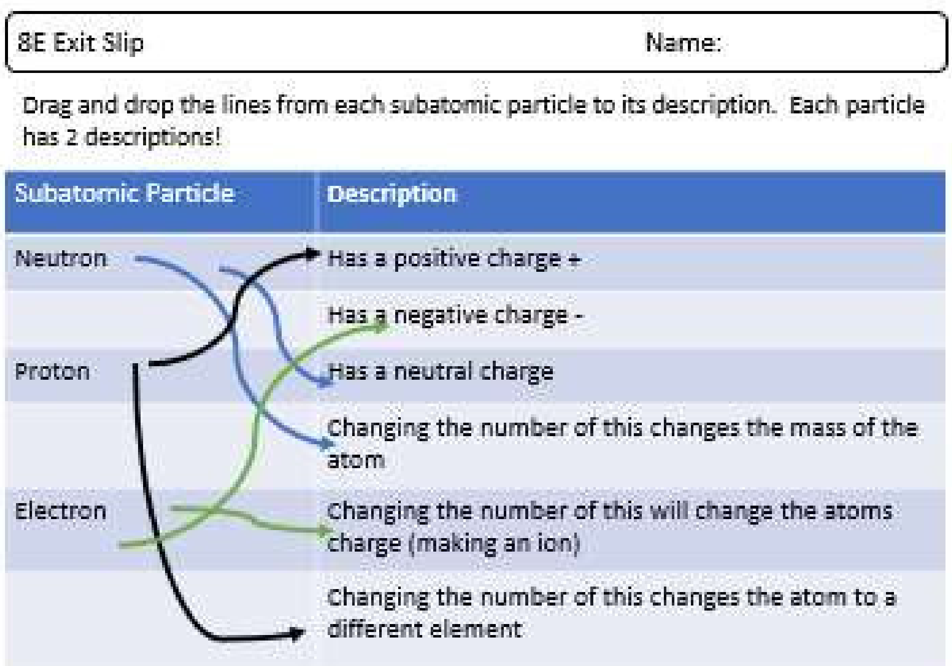


8E Exit Slip Name:

Draw a line from each subatomic particle to its description. Each particle has 2 descriptions!

Subatomic Particle	Description
Neutron	Has a positive charge +
	Has a negative charge -
Proton	Has a neutral charge
	Changing the number of this changes the mass of the atom
Electron	Changing the number of this will change the atoms charge (making an ion)
	Changing the number of this changes the atom to a different element

Answer Key



8E Exit Slip Name:

Drag and drop the lines from each subatomic particle to its description. Each particle has 2 descriptions!

Subatomic Particle	Description
Neutron	Has a positive charge +
	Has a negative charge -
Proton	Has a neutral charge
	Changing the number of this changes the mass of the atom
Electron	Changing the number of this will change the atoms charge (making an ion)
	Changing the number of this changes the atom to a different element

Lesson Six - Chemical Reactions and Properties

BC Curriculum Content: The behavior of matter can be explained by the KMT and Atomic Theory.	**Unit Guiding Question:** How do particles explain an element's properties?
Lesson Goals: • I can identify physical and chemical changes. • I understand how particles are responsible for the characteristics of matter.	
UDL Checkpoints **Multiple means of representation:** Provide options for perception: Options for customizing the display of information. Provide alternatives for auditory and visual information. Provide options for language and symbols: Illustrate through multiple media. Provide options for comprehension: Activate or supply background knowledge. Highlight patterns, critical features, big ideas, and relationships. Maximize transfer and generalization. **Multiple means of action and expression:** Provide options for physical action: Vary the methods for response and navigation. Provide options for Expression & Communication: Use multiple media for communication. **Multiple means of engagement:** Provide options for recruiting interest: Optimize relevance, value, and authenticity. Provide options for sustaining effort and persistence: foster collaboration and community.	

Processing Tasks →				
I need to… *Understand there are chemical and physical changes* Access	I must… *Identify chemical and physical changes* All	I can … *Identify three differences between chemical and physical changes* Most	I could… *Think of my own examples of chemical and physical changes* Few	I can try to… *Explain chemical and physical changes using particles* Challenge

Lesson Rationale

This lesson begins to bring the main ideas of the unit together contrasting physical changes of state with chemical changes. It reviews changes of state as a physical change and extends our study of subatomic particles to relate them to chemical changes (reactions). Students create a chart to contrast the two changes and use it to try to identify changes. Students have the options to work with peers or alone. Videos are used to give variety from teacher lecture and a response card type activity is used as a check for understanding. All resources are attached to this lesson plan and available as fillable documents in Appendix F.

Activating Prior Knowledge

Have students brainstorm about what they have learned about how particles in matter influence its properties and behavior. The teacher can circulate the room and assess students understanding of the topic so far. The teacher should address any misconceptions and have the students share their ideas with a partner and then review as a class.

Student Goal Setting

Have students check-in as and show them the processing tasks for today. Remind students to try their best which is different for everyone. Have students think about how last class went and have them set a goal for today. The teacher can also check in with specific students if appropriate.

Building Knowledge

- Review the ideas that changes in state are physical changes that involve particle movement and that subatomic particles in atoms give them their properties. Have students fill out the attached Chemical Versus Physical Change Notes (Figure 15) which overviews the main ideas so far.

- Have students watch the following videos and try to write key ideas about physical changes and chemical changes in note paper or on the attached T-Chart (Figure 16). Students can work in pairs or on their own. Review the lists with the class highlighting the key differences.
    - Changes in state https://www.youtube.com/watch?v=xYU7RSoOZ0U&t=32s
    - Why do atoms bond? https://www.youtube.com/watch?v=JOL-nUt_vfo
    - Nuclear Fission and Fusion https://www.youtube.com/watch?v=xrk7Mt2fx6Y
- Have the students classify a change as chemical or physical Using the Chemical or Physical Change Presentation (Figure 17). Using the response cards from lesson three (Figure 9) or other response signals (such as pointing to a corner of the room marked chemical or a corner marked physical) helps include all students. This presentation relates the chemical and physical changes to the real world. By observing students answers the teacher can get an idea as to students understanding.
- As an extension, students can think of changes and try to classify them as chemical or physical changes as well as explain why they are changing using the particle model of matter.

Student Reflection

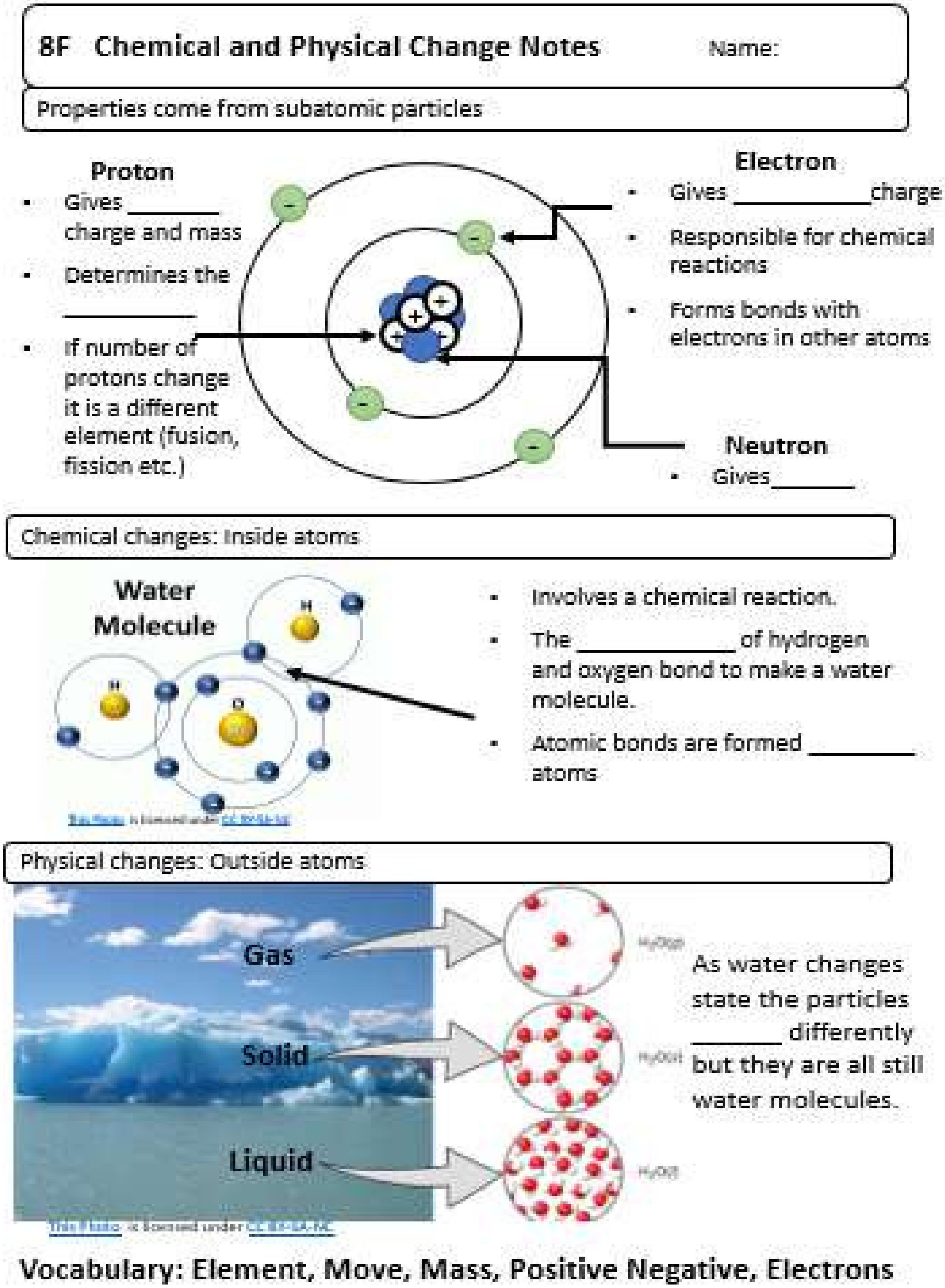
Have students reflect on how they did today. What did they do well? Did they achieve their goal? What could they change for next time? Check-in with students who are having difficulties to help them with goal setting and to build relationships. The focus of this is to develop a growth mindset in students and teachers; that effort can increase performance and help achieve goal.

Teacher Reflection

- What? What did you use? Did you change, add, or remove anything to the lesson?
- So what? Do you feel the resources helped foster inclusion? Increased motivation, allowed for many students to participate and learn?
- Now what? What would you do differently next time? Are there any aspects of the lesson you will continue to use?

Lesson Six Resources

Figure 15: Chemical and Physical Change Notes



8F Chemical and Physical Change Notes Name:

Properties come from subatomic particles

Proton

- Gives ________ charge and mass
- Determines the ___________
- If number of protons change it is a different element (fusion, fission etc.)

Electron

- Gives ____________charge
- Responsible for chemical reactions
- Forms bonds with electrons in other atoms

Neutron

- Gives_______

Chemical changes: Inside atoms

Water Molecule

- Involves a chemical reaction.
- The ______________ of hydrogen and oxygen bond to make a water molecule.
- Atomic bonds are formed _________ atoms

Physical changes: Outside atoms

Gas

Solid

Liquid

As water changes state the particles ________ differently but they are all still water molecules.

Vocabulary: Element, Move, Mass, Positive Negative, Electrons

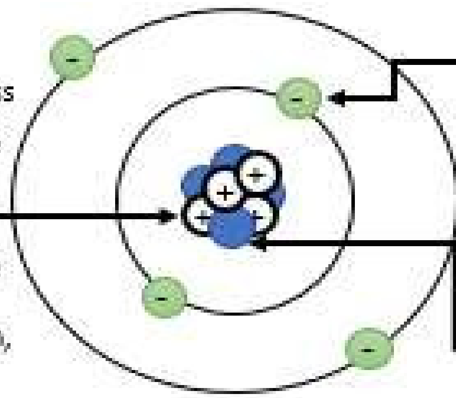
Answer Key:

8F Chemical and Physical Change Notes

Properties come from subatomic particles

Proton

- Gives **positive** charge and mass
- Determines the **element**
- If number of protons change it is a different element (fusion, fission etc.)



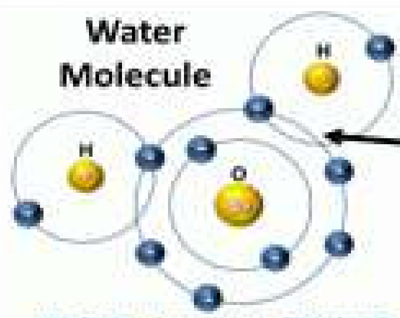
Electron

- Gives **negative** charge
- Responsible for chemical reactions
- Forms bonds with electrons in other atoms

Neutron

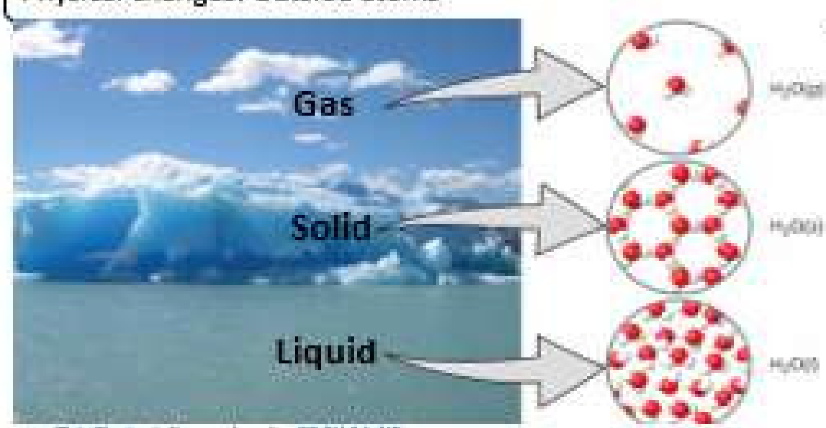
- Gives **mass**

Chemical changes: Inside atoms



- Involves a chemical reaction.
- The **electrons** of hydrogen and oxygen bond to make a water molecule.
- Atomic bonds are formed **between** atoms

Physical changes: Outside atoms



As water changes state the particles **move** differently but they are all still water molecules.

Figure 16: T- Chart

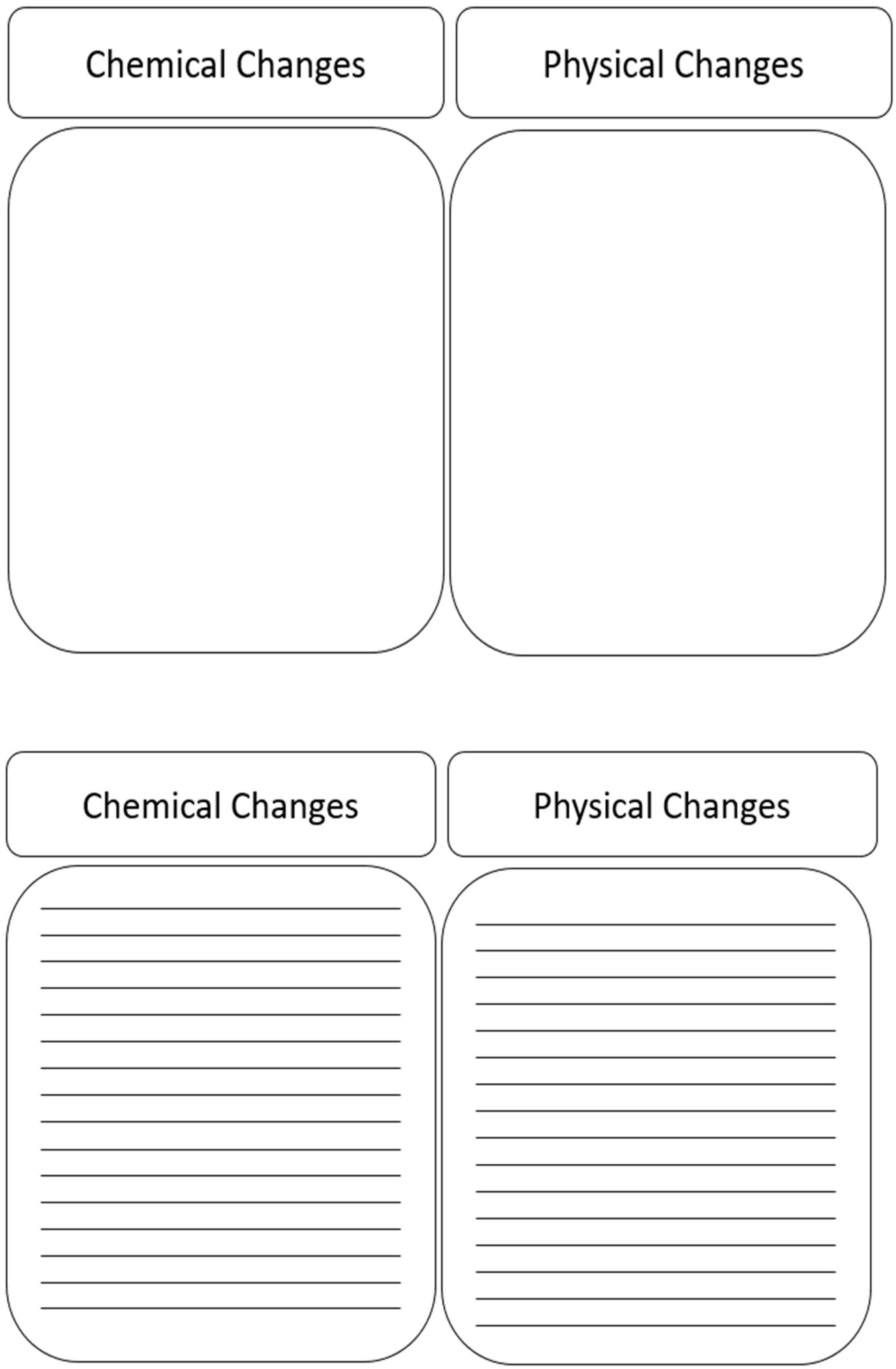


Figure 17: Chemical and Physical Change Presentation

Are the following changes Chemical or Physical changes?

Take out your chemical and physical change chart please!

* All pictures sourced from Creative Commons

Breaking a Rock?

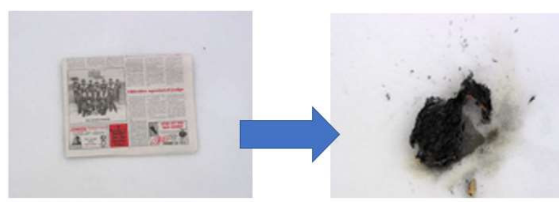
Breaking a Rock?

- Physical change

Burning Paper?

Burning Paper?

- Chemical Change

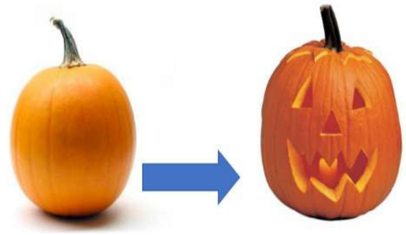


Ice Melting?

Ice Melting?

- Physical Change

Carving a pumpkin?



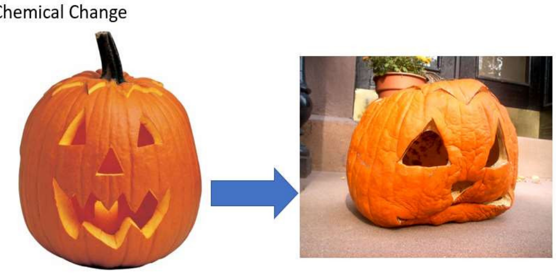
Carving a pumpkin?

- Physical Change

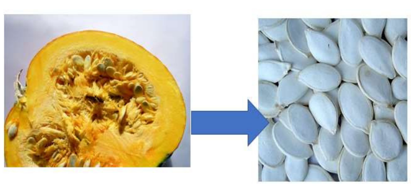
A pumpkin rotting?

A pumpkin rotting?

- Chemical Change

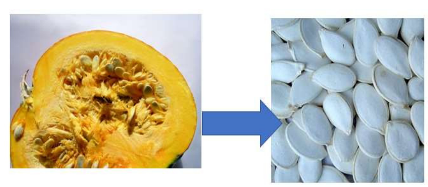


Toasting pumpkin seeds?



Toasting pumpkin seeds?

- Chemical Change

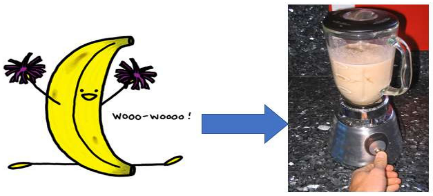


A car rusting?

A car rusting?

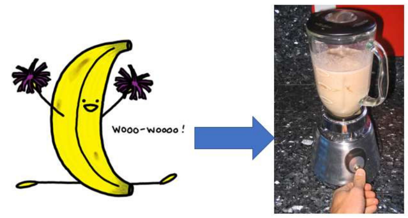
- Chemical Change

Blending a banana?

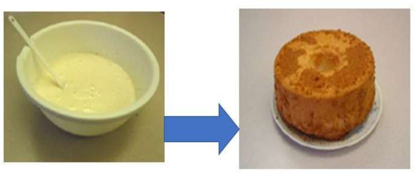


Blending a banana?

- Physical Change

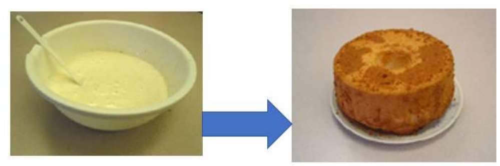


Making a cake?

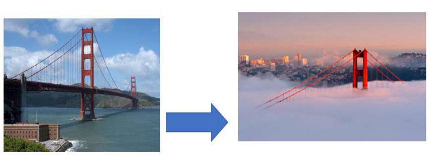


Making a cake?

- Chemical Change



Fog forming



Fog forming

- Physical Change

Making elephant toothpaste?

Making elephant toothpaste?

- Chemical Change

Lesson Seven - Making Connections

BC Curriculum Content: The behavior of matter can be explained by the KMT and Atomic Theory	**Unit Guiding Question:** How do particles explain an element's properties?
Lesson Goals: • I can show my understanding of how particles are responsible for the characteristics of matter	
UDL Checkpoints **Multiple means of Representation:** Provide options for Comprehension: Highlight patterns, critical features, big ideas, and relationships. Guide information processing and visualization. Maximize transfer and generalization. **Multiple means of Action and Expression:** Provide options for Expression & Communication: Build fluencies with graduated levels of support for practice and performance. Provide options for EF: Facilitate managing information and resources. **Multiple means of Engagement:** Provide options for Sustaining Effort & Persistence: Foster collaboration and community.	

Processing Tasks →				
I need to… *Think how particles change matter* Access	I must… *Complete the Venn diagram* All	I can … *Write OR answer questions about the unit* Most	I could… *Share my question with others* Few	I can try to… *Research my question* Challenge

Lesson Rationale

This lesson brings the big ideas of the unit together and prepares students for the final assessment. Students will be encouraged to make connections between the ideas of the unit and create their own questions about what we have been studying. The focus of the lesson is to prepare students for the final assessment for the unit.

This unit explored particles and their impacts on the behavior of matter. We explored two big ideas about particles and matter: 1) that changes of state are associated with heat (energy) increasing or decreasing particle movement and 2) that subatomic particles are responsible for matters characteristics/ behaviour. Students will fill out a Venn Diagram on these topics which will be used as information to start their unit project. Teachers can see how students do at filling out the diagrams and assess students understanding and adapt accordingly (add lessons for the whole class, have activities for some students to complete etc.). All resources are attached to this lesson plan and available as fillable documents in Appendix G.

Activating Prior Knowledge

Have students brainstorm about how particles are responsible for properties of matter. It may be beneficial to review the ideas that changes in state are physical changes that involve particle movement and subatomic particles that make up atoms give atoms their properties.

Student Goal Setting

Have students check-in and show them the processing tasks for today. Remind students to try their best which is different for everyone. Have students think about how last class went and have them set a goal for today. The teacher can also check in with specific students if appropriate.

Making Connections

- Have students fill out the Venn diagram (Figure 18) on particles effect on matter. The subheadings could be 'Changes of State' and 'Parts of the Atom'. Students can fill the Venn diagram out on their own or in partners then review the main ideas with the class.
- The teacher could have students who need more help work with the teacher or in small groups to recap main ideas for the lesson while others move on to formulating questions.

Formulating Questions

Have students make questions about the unit. This could include things they are curious about, questions they still have about the unit, or things they want clarified. This can be an assessment of learning to help the teacher see how students understood the unit. If a student is very interested in their question, they could answer it as their unit assessment in place of the projects that will be presented next class. The questions could be used as an exit slip and teacher could address questions at the beginning of next class.

Student Reflection

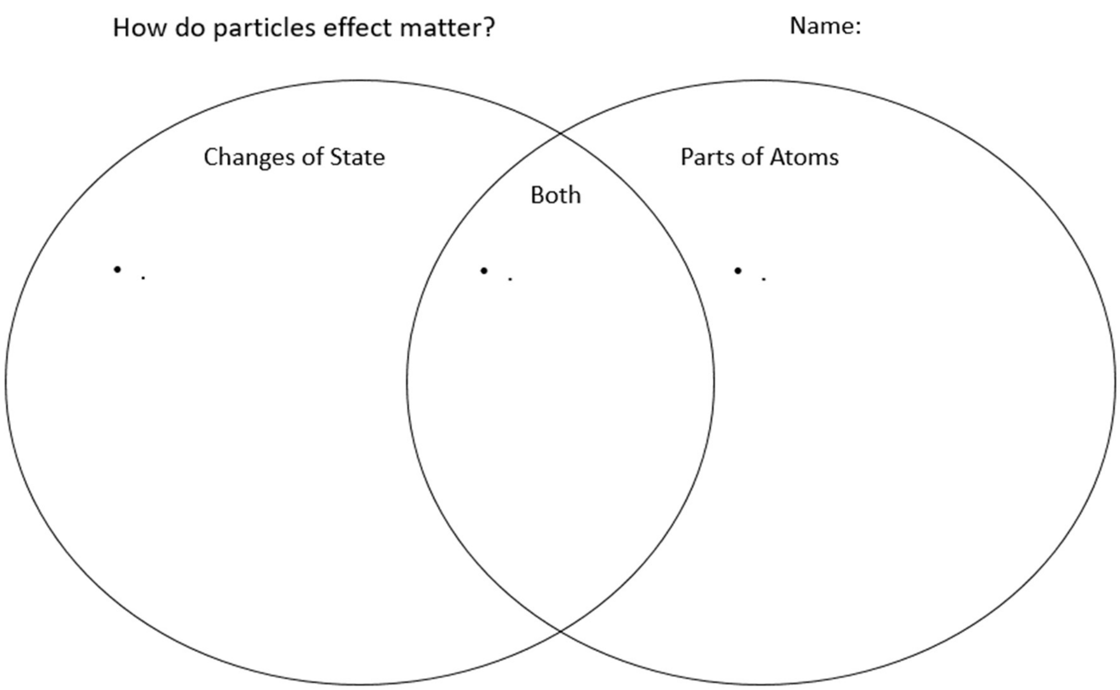
Have students reflect on how they did today. What did they do well? Did they achieve their goal? What could they change for next time? Check-in with students who are having difficulties to help them with goal setting and to build relationships. The focus of this is to develop a growth mindset in students and teachers.

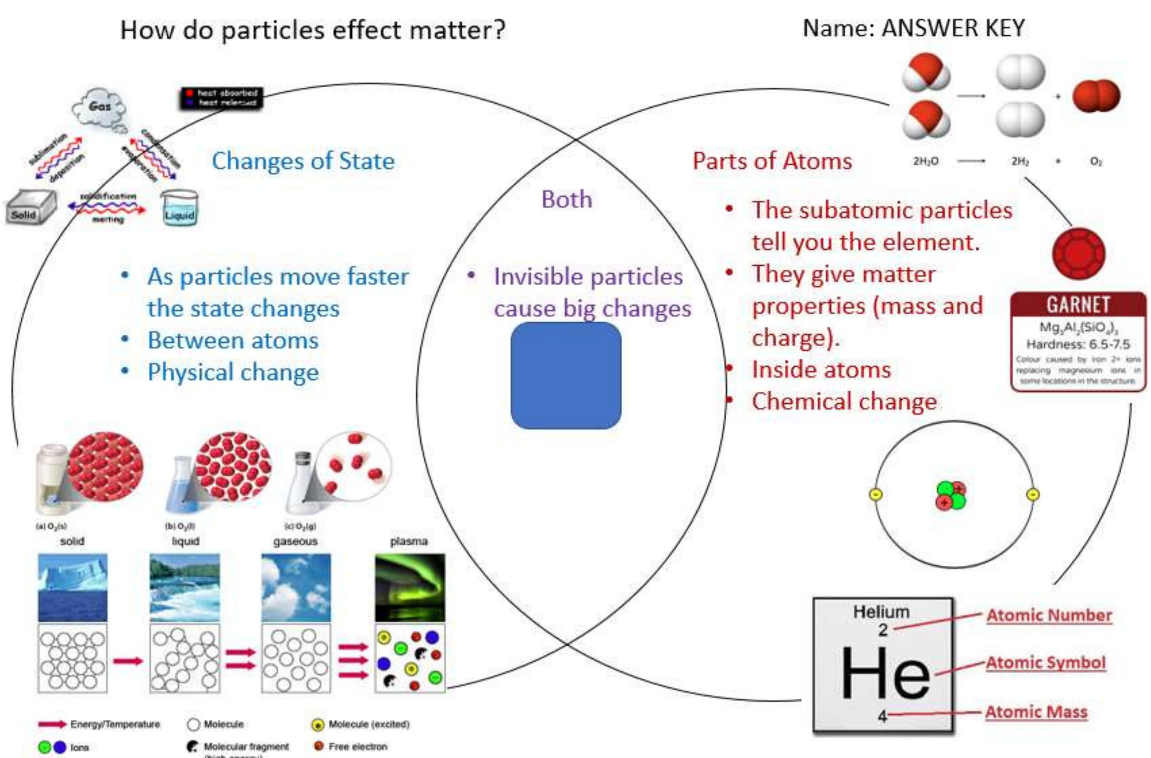
Teacher Reflection

- What? What did you use? Did you change, add, or remove anything to the lesson?
- So what? Do you feel the resources helped foster inclusion? Increased motivation, allowed for many students to participate and learn?
- Now what? What would you do differently next time? Are there any aspects of the lesson you will continue to use?

Lesson Seven Resources

Figure 18: Venn Diagram





Lesson Eight - Assessment of Learning

BC Curriculum Content: The behavior of matter can be explained by the KMT and Atomic Theory	**Unit Guiding Question:** How do particles explain an element's properties?
Lesson Goals: • I can show my understanding of how particles are responsible for the characteristics of matter.	
UDL Checkpoints **Provide multiple means of representation:** Provide options for Perception: Offer ways of customizing the display of information. **Multiple means of action and expression:** Provide options for physical action: Optimize access to tools and assistive technologies. Provide options for EF: Guide appropriate goal setting, support planning and strategy development, facilitate managing information and resources and enhance capacity for monitoring progress. **Multiple means of engagement:** Provide options for recruiting interest: Optimize individual choice and autonomy. Provide options for sustaining effort & persistence: Vary demands and resources to optimize challenge. Foster collaboration and community. Provide options for self-regulation: Develop self-assessment and reflection.	

Processing Tasks →				
I need to… *Show my understanding* Access	I must… *Complete a project* All	I can … *Include the main ideas and some vocabulary* Most	I could… *Include all vocabulary and show some connections* Few	I can try to… *Show multiple connections and advanced understanding* Challenge

Lesson Rationale

This end of unit activity provides students with an opportunity to bring together and display their understanding of the big ideas of the unit. This unit explored particles and their impacts on the behavior of matter. We explored two big ideas about particles and matter: 1) that changes of state are associated with heat (energy) increasing or decreasing particle movement and 2) that subatomic particles are responsible for matters characteristics/behaviour.

Students will create a project to demonstrate their understanding of the key concepts and vocabulary. The attached rubric and assignment sheets (Figure 19) will help students understand what is expected and how the activities we have completed so far prepared them for this assessment. The assignment sheets give students options as to how they demonstrate their learning. The open-ended projects try to be accessible and allow students to choose a mode of showing their learning that they are comfortable with. All students will demonstrate the big ideas and students who are able can go deeper into the topic. For students on modified programs or those with special needs it is important to consult (with special education teachers, counselors, and the student) to ensure that the project requirements are appropriate. All resources are attached to this lesson plan and available as fillable documents in Appendix H.

Planning and Goal Setting

- Students will need adequate time and support to plan, create and show their project. Projects often have multiple steps and require executive functioning skills that many middle school students are still developing. Some students will need additional help choosing and planning their project while others may benefit from more autonomy.
- The rubric and assignment sheets contain planning pages (Figure 19). Providing exemplars (see attached links in project assignment sheets) and direct instruction on time management and how to plan and work in a group may be beneficial. Supporting students in setting and completing goals can be very important. At the beginning of the class have students set goals that they want to complete during the class (this is a good time for review of a goal setting and time management strategy), then give students time at the end of class to reflect on their work that class.

- Having ‘Workshop Walks’ (like a gallery walk but for projects in process) where students explain their plans to others can be beneficial as they allow students to see how others plan, and it can give inspiration and motivation. It can also allow peers and teacher to give feedback about plans (there are multiple feedback formats out there such as ‘two stars and a wish’ etc.). During this time, the teacher should strive to provide students with specific descriptive feedback on areas they are doing well and gently support them in areas where they may need improvement.

Project Options

Teacher should present the different options for final projects providing as many examples and non- examples as possible. The projects are listed below but the rubrics and assignment sheets (Figure 19) also give additional information. It is helpful for the teacher to review the rubrics with the class, so they know what is expected of them.

- **Interview:** Students will conduct an interview to showcase their learning. One student is the journalist the other the expert. The journalist asks questions of the expert that showcase the key concepts and vocabulary of the unit. This could be recorded and posted to students’ portfolio.
- **Mind Map:** Students create a mind map of that showcases the key concepts and vocabulary of the unit and shows how the ideas are connected.
- **Presentation or Song:** Using presentation software or other visuals, students create a presentation that showcases the key concepts and vocabulary of this unit.

Demonstration of Learning

Students should showcase their learning to the teacher and possibly the class either in a ‘Gallery Walk’ presentation or other form of presenting (showing their interview clip, presenting their presentation etc.). There is a ‘Descriptive Feedback’ form (Figure 20) that students can use to give feedback to their peers. If this is the first-time students are completing the form it may be beneficial for the teacher to show students how to fill it out and give examples and non-examples of high-quality feedback.

Student Reflection

Have students reflect on how they did. What did they do well? Did they achieve their goal? What could they change for next time? This could be a good time to check-in with students who are having difficulties. This can be very important with large projects as they involve well developed EF skills that middle school students may lack. Checking in with students daily allows both the student and the teacher to understand how the project is progressing and can allow the teacher to provide proper supports and give feedback before the project is due. If it is the last class of the unit have them reflect how they did on their project. What they did well and what they could change for next time?

Teacher Reflection

- What? What did you use? Did you change, add, or remove anything to the lesson?
- So what? Do you feel the resources helped foster inclusion? Increased motivation, allowed for many students to participate and learn?
- Now what? What would you do differently next time? Are there any aspects of the lesson you will continue to use? Is there anything you would add to the unit next time?

Lesson Eight Resources

Figure 19: Rubric and Assignment Sheets

Chemistry Final Project Rubric

Name:

Big Ideas and Vocabulary	Meeting	Exceeding	Excelling
Explain or show how matter is made of particles.	Student can comprehend idea and vocabulary but has difficulty connecting words to big ideas.	Student shows they know vocabulary and is making connections between words and big ideas.	Student shows they know vocabulary, makes connections with the big ideas
Explain or show how matter changes state. Vocabulary: • Solid • Liquid • Gas Extended: Melting, freezing, condensation, evaporation, deposition, sublimation, energy, heat, movement, kinetic molecular theory, plasma	Student can comprehend idea and vocabulary but has difficulty connecting words to big ideas.	Student shows they know vocabulary and is making connections between words and big ideas.	Student shows they know vocabulary, makes connections with the big ideas
Explain or show how subatomic particles relate to behaviour of matter. Vocabulary: • Atom • Proton • Neutron • Electron • Mass • Charge • Element Extended: nucleus, orbit, leptons, quarks, compound, molecule	Student can comprehend idea and vocabulary but has difficulty connecting words to big ideas.	Student shows they know vocabulary and is making connections between words and big ideas.	Student shows they know vocabulary, makes connections with the big ideas

Adapted from Brownlie et al. 2011

8H Chemistry Unit Final Project

Name:

This project will showcase what you know about the big ideas of our Chemistry Unit:

How do particles explain the behaviour of matter?

Pick one of the following projects:

Interview
A scientist has just discovered that matter is made of particles that explain matters behaviour. A journalist will interview the scientist about the discovery to get the full story.

Mind Map
Create a mind map or drawing of that showcases the key concepts and vocabulary of the unit.

Presentation or Song
Create a presentation or song using software or other visuals. To explain the key concepts and vocabulary of this unit.

INTERVIEW
8H Chemistry Unit Final Project Name:

This project will showcase what you know about the big ideas of our Chemistry Unit:

How do particles explain the behaviour of matter?

Interview

A scientist has just discovered that matter is made of particles and will demonstrate the discovery at an upcoming conference. A journalist will interview the scientist about the discovery to get the full story. The scientist is trying to build excitement to get people to come to the conference.

For examples please see interviews with:
Elon Musk: https://www.youtube.com/watch?v=zIwLWfaAg-8,
Bill Nye: https://www.youtube.com/watch?v=eCl-A2Y6GIU,
Neil Degrass Tyson: https://www.youtube.com/watch?v=hLPPE3_DVCw

Explain or show the following ideas and vocabulary:

- ❑ How matter is made of particles.
- ❑ How matter changes state.
- ❑ How subatomic particles relate to behaviour of matter.

Vocabulary:

- Solid
- Liquid
- Gas
- Atom
- Proton
- Neutron
- Electron
- Mass
- Charge
- Element

Extended: Melting, freezing, condensation, evaporation, deposition, sublimation, nucleus, orbit, leptons, quarks, compound, molecule, plasma

Project Planning Interview

Name(s):

1. Assign roles:

Journalist ______________________ Scientist: _________________________

2. Write key questions:

Examples: How will you demonstrate your discovery? Why is this discovery important? (The journalist should ask lots of questions to get the 'whole story' to fully explain the scientist discovery.)

Journalist: Please explain your discovery?

Scientist: I discovered that matter is made of tiny particles that are constantly moving….

J:____

S: ____

J:____

S: ____

J:____

S: ____

J:____

S: ____

J:____

S: ____

J:____

S: ____

3. Describe props and materials you will need:

____

____

4. Describe your characters? (kooky/mad scientist etc.)

____

____

✓ Check the rubric to see if you included the big ideas and vocabulary .

MIND MAP
8H Chemistry Unit Final Project

Name:

This project will showcase what you know about the big ideas of our Chemistry Unit:

How do particles explain the behaviour of matter?

Mind Map

Create a mind map or poster that showcases the key concepts and vocabulary of the unit. Use words, short phrases and pictures with arrows and colours to show ideas and how they are related. This can be done on paper or online https://www.mindmup.com/#storage.

For examples please see:
Mind Maps:
https://www.youtube.com/watch?v=-Y1HJMuqAPY
https://www.braindirector.com/the-easiest-and-correct-way-to-make-a-mind-map/
Poster:
https://www.youtube.com/watch?v=agtgnJP3KoQ

Explain or show the following ideas and vocabulary:

- ❑ How matter is made of particles.
- ❑ How matter changes state.
- ❑ How subatomic particles relate to behaviour of matter.

Vocabulary:

- Solid
- Liquid
- Gas
- Atom
- Proton
- Neutron
- Electron
- Mass
- Charge
- Element

Extended: Melting, freezing, condensation, evaporation, deposition, sublimation, nucleus, orbit, leptons, quarks, compound, molecule, plasma

Presentation or Song
8H Chemistry Unit Final Project

Name:

This project will showcase what you know about the big ideas of our Chemistry Unit:

How do particles explain the behaviour of matter?

Presentation or Song

Create a presentation or song using software or other visuals that explains the key concepts and vocabulary of this unit.

For examples please see:
Asap Science: https://www.youtube.com/watch?v=7sKp9R5BOEk
They Might be Giants: https://www.youtube.com/watch?v=Uy0m7jnyv6U
Mr Parr: https://www.youtube.com/watch?v=U50qw3HTvc4

Explain or show the following ideas and vocabulary:

- ❑ How matter is made of particles.
- ❑ How matter changes state.
- ❑ How subatomic particles relate to behaviour of matter.

Vocabulary:

- Solid
- Liquid
- Gas
- Atom
- Proton
- Neutron
- Electron
- Mass
- Charge
- Element

Extended: Melting, freezing, condensation, evaporation, deposition, sublimation, nucleus, orbit, leptons, quarks, compound, molecule, plasma

Project Planning

Name(s):

1. Type of project: ____

2. Materials you will need: ____

3. Brain storm about the big ideas of the unit below:

How is matter made of particles?

How will I show this?

How does matter change state?

How will I show this?

How do subatomic particles relate to behaviour of matter?

How will I show this?

Vocabulary: Solid, liquid, gas, atom, proton, neutron, electron, mass, charge element
Extended: Melting, freezing, condensation, evaporation, deposition, sublimation, energy, heat, movement, kinetic molecular theory, plasma nucleus, orbit, leptons, quarks, compound, molecule

Check the rubric

Figure 20: Descriptive Feedback Sheet

Chemistry Final Project
Descriptive Feedback

Name:

Big Ideas and Vocabulary	Meeting	Exceeding	Excelling
Explain or show how matter is made of particles.			
Explain or show how matter changes state.			
Explain or show how subatomic particles relate to behaviour of matter.			

I liked the way you...

____

Maybe next time you could...

____

Adapted from Brownlie et al. 2011

References

Adamson, R. M., & Lewis, T. J., (2017). A Comparison of three opportunity-to-respond strategies on the academic engaged time among high school students who present challenging behavior. *Behavioral Disorders, 42,* 41-51.

Alasim, K. (2018). Participation and Interaction of deaf and hard of hearing students in inclusion classroom. *International Journal of Special Education, 33*(2), 493-506.

Al-Azawei, A., Serenelli, F., & Lundqvist, K. (2016). Universal Design for Learning (UDL): A content analysis of peer reviewed journals from 2012 to 2015. *Journal of the Scholarship of Teaching and Learning, 16*(3), 39-56.

Alquraini, T. & Gut D. (2012). Critical components of successful inclusion of students with severe disabilities: literature review. *International Journal of Special Education, 27*(1), 42–59.

Anderson, P. (2002). Assessment and development of executive function (EF) during childhood. *Child Neuropsychology, 8*(2), 71-82.

Anderson, V. A., Anderson, P., Northam, E., Jacobs, R., & Mikiewicz, O. (2002). Relationships between cognitive and behavioral measures of executive function in children with brain disease. *Child Neuropsychology, 8*(4), 231–240.

Atkins, S. & Murphy, K. (1993). Reflection: A review of the literature. *Journal of Advanced Nursing, 18*, 1188–1192.

Awada, G. & Plana, M.G.C. (2018). Multiple strategies approach and EFL reading comprehension of learners with Dyslexia: Teachers' perceptions. *International Journal of Instruction, 11*(3), 463-479.

Barkley, A. R. (2012). *Executive functions. What they are, how they work and why they evolved*. New York, NY: The Guilford Press.

Barkley, A. R. (2016). Recent longitudinal studies of childhood attention-deficit/hyperactivity disorder: Important themes and questions for further research. *Journal of Abnormal Psychology, 125*(2), 248-255.

Bender, W. N., Boon, R. T., Hinrichs, J., & Lawson, C. (2008). Instructional tactics that facilitate inclusion: Are we doing successful inclusion in secondary classrooms? *Journal of the American Academy of Special Education Professionals, 5,* 5-17.

Berninger, V., Abbott, R., Cooke, C. R., & Nagy, W. (2017). Relationships of attention and executive functions to oral language, reading, and writing skills and systems in middle childhood and early adolescence. *Journal of Learning Disabilities, 50*(4), 434-449.

Berry, R. (2006). Teacher talk during whole-class lessons: Engagement strategies to support the verbal participation of students with learning disabilities. *Learning Disabilities Research & Practice, 21*(4), 211-232.

Best, J. R., Miller, P. H. & Jones, L. L. (2009). Executive functions after age 5: changes and correlates. *Developmental Review, 29*(3), 180–200.

Bradley, R. (2016). 'Why single me out?' Peer mentoring, autism, and inclusion in mainstream secondary schools. *British Journal of Special Education, 43*(3), 272-288.

Browder, D. M., & Spooner, F. (Eds.). (2006). *Teaching language arts, math, and science to students with significant cognitive disabilities*. Baltimore, MD: Paul H. Brookes.

Brownlie, F., Fullerton, C., & Schnellert, L. (2011). *It's all about thinking: Collaborating to support all learners in mathematics and science.* Winnipeg, MB: Portage and Main Press.

Capp, M.J. (2017). The effectiveness of universal design for learning: a metanalysis of literature between 2013 and 2016. *International Journal of Inclusive Education, 21*(8), 791-807.

Carter, E.W., Sisco, L.G., Melekoglu, M.A. & Kurkowski, C. (2007). Peer support as an alternative to individually assigned paraprofessionals in inclusive high school classrooms. *Research and Practice for Persons with Severe Disabilities, 32*(4), 213-227.

Casale-Giannola, D. (2012). Comparing inclusion in the secondary vocational and academic classrooms: Strengths, needs, and recommendations. *American Secondary Education, 40*, 26-42.

Casey, B. J., Giedd, J. N., & Thomas, K. M. (2000). Structural and functional brain development and its relation to cognitive development. *Biological Psychology, 54*(3), pp. 241–257.

Cihak, D.F. & Castle, K. (2011). Improving expository writing skills with explicit and strategy instructional methods in inclusive middle school classrooms. *International Journal of Special Education, 26*(3), 106-113.

Clarke, L.S., Haydon, T., Bauer, A. & Epperly, A.C. (2016). Inclusion of students with an intellectual disability in the general education classroom with the use of response cards. *Preventing School Failure, 60*(1), 35-42.

Clavo, A. & Bialystok, E. (2015). Independent effects of bilingualism and socioeconomic status on language ability and executive functioning. *Cognition, 130*(3), 278-288.

Cooper-Kahn, J. & Foster, M. (2013). *Boosting executive skills in the classroom: A practical guide for educators.* San Francisco, CA: Jossey-Bass.

Copeland, S. R., Hughes, C., Carter, E.W., Guth, C., Presley, J.A., Williams, C. R., & Fowler, S.E. (2004). Increasing access to general education: Perspectives of participants in a high school peer support program. *Remedial and Special Education, 25*(6), 342-352.

Courey, S. J., Tappe, P., Siker, J., & LePage, P. (2012). Improved Lesson Planning with Universal Design for Learning (UDL). *Teacher Education and Special Education: The Journal of the Teacher Education Division of the Council for Exceptional Children*.

Creswell, J. W. (2015). *Educational research: Planning, conducting, and evaluating quantitative and qualitative research* (5th ed). Boston: Pearson.

Darrow, A. (2009). Barriers to effective inclusion and strategies to overcome them. *General Music Today, 22*(3), 29-31.

Dieker, L. (2007). *Demystifying secondary inclusion: Powerful school-wide & classroom strategies*. Port Chester, NY: Dude Publishing.

Denckla, M. B. (2007). Executive function: Binding together the definitions of attention-deficit/hyperactivity disorder and learning disabilities. In L. Meltzer (Ed.), *Executive Function in Education: From theory to practice* (pp. 5-18). New York, NY: The Guilford Press.

DePrince, A. P., Weinzierl, K. M. & Combs, M. D. (2009). Executive function performance and trauma exposure in a community sample of children. *Child Abuse and Neglect, 33*(6), 353-361.

Dewey, J. (1960). *The quest for certainty: A study of the relation of knowledge and action*. New York, NY: G.P. Putnam's.

Diamond, A. (2000). Close interrelation of motor development and cognitive development and of the cerebellum and prefrontal cortex. *Child Development, 71,* 44–56.

Diamond, A. & Lee, K. (2011). Interventions shown to aid executive function development in children 4 to 12 years old. *Science, 333(6045).* 959-964.

Doğanay Bilgi, A., & Özmen, E. R. (2014). The impact of modified multi-component cognitive strategy instruction in the acquisition of metacognitive strategy knowledge in the text comprehension process of students with mental retardation. *Educational Sciences: Theory & Practice, 14*(2), 707–714.

Donker, A. S., de Boer, H., Kostons, D., Dignath-van Ewijk, C. C., & van der Werf, M. P. C. (2014). Effectiveness of learning strategy instruction on academic performance: A meta-analysis. *Educational Research Review, 11,* 1–26.

Driscoll, J. (1994). Reflective practice for practice. *Senior Nurse, 13*(7), 47-50.

Duchaine, E.L, Jolivette, K., Fredrick, L.D. & Alberto, P.A. (2018). Increase engagement and achievement with response cards: Science and Mathematics inclusion classes. *Learning Disabilities: A Contemporary Journal, 16*(2), 157-176.

DuPaul, G.J., Eckert, T.L. & Vilardo, B. (2012). The effects of school-based interventions for attention deficit hyperactivity disorder: A meta-analysis 1996-2010. *School Psychology Review, 41*(4), 387-412.

DuPaul, G.J. & Weyandt, L.L. (2006). School-based interventions for children and adolescents with Attention-Deficit/Hyperactivity Disorder: Enhancing academic and behavioral outcomes. *Education and Treatment of Children, 29*(2), 341-358.

Farah, M. J., Shera, D. M., Savage, J. M., Betancourt, L., Giannetta, J. M., Brodsky, N. L., Malmud, E. K. & Hurt, H. (2006). Childhood poverty: Specific associations with neurocognitive development. *Brain Research, 1110,* 166-174.

Fisher, K. W. & Daley, S. G. (2007). Connecting cognitive science and neuroscience to education: Potentials and pitfalls in inferring executive processes. In L. Meltzer (Ed.), *Executive Function in Education: From theory to practice* (pp. 55-72). New York, NY: The Guilford Press.

Fisher, R. (2002). Shared thinking: Metacognitive modeling in the literacy hour. *Reading, 36(2)*, 65–67.

Fleer, M., Harrison, L., Walker, S. & Veresov, N. (2017). Working with teachers' pedagogical strengths: The design of executive function activities for play-based programs. *Australasian Journal of Early Childhood, 42*(4), 47-55.

Florian, L. & Beaton, M. (2018). Inclusive pedagogy in action: getting it right for every child. *Journal of Inclusive Education, 22*(8), 870-884.

Fox, N.E. & Ysseldyke, J.E. (1997). Implementing inclusion at the middle school level: Lessons from a negative example. *64*(1), 7-18.

Ganly, P. (2017). Taking time to pause: Engaging with a gift of reflective practice. *Innovations in Education and Teaching International, Feb,* 1-11.

Garcia-Campos, M., Canabal, C., & Alba-Pastor, C. (2018). Executive functions in universal design for learning: Moving towards inclusive education. *International Journal of Inclusive education, online,* 1-15. https://doi.org/10.1080/13603116.2018.1474955

Gaskins, B. N. & Pressley, M. (2007). Teaching metacognitive strategies that address executive function processes within a schoolwide curriculum. In L. Meltzer (Ed.), *Executive Function in Education: From theory to practice* (pp. 261-286). New York, NY: The Guilford Press.

Hinshaw, S.P., Carte, E.T., Fan, C., Jassy, J.S. & Owens, E.B. (2007). Neuropsychological functioning of girls with attention-deficit/hyperactive disorder followed prospectively into adolescence: Evidence for continuing deficits? *Neuropsychology, 21*(2), 263-273.

Hitchcock, C.H., Rao, K., Chang, C.C. & Yuen J.W.L. (2016). TeenACE for science: Using multimedia tools and scaffolds to support writing. *Rural Special Education Quarterly, 35*(2), 10-23.

Holmes, J., Gathercole, S., & Dunning. (2009). Adaptive training leads to sustained enhancement of working memory in children. *Developmental Science, 12*(4), 9-15.

Horrocks, J., G. White, and L. Roberts. 2008. Principals' attitudes regarding inclusion of children with autism in Pennsylvania public schools. *Journal of Autism and Developmental Disorders, 38,* 1462–73.

Hudson, M.E., Browder, D.M. & Wood, L.A. (2013). Review of experimental research on academic learning by students with moderate and severe intellectual disabilities in general education. *Research & Practice for Persons with Severe Disabilities, 38*(1), 17-29.

Humphries, T., Cardy, J. O., Working, D. E., & Peets, K. (2004). Narrative comprehension and retelling abilities of children with nonverbal learning disabilities. *Brain and Cognition, 56*(1), 77–88.

Jacob, R. & Parkinson, J. (2015). The potential for school-based interventions that target executive function to improve academic achievement: A review. *Review of Educational Research, 85*(4), 512-552.

Jacobsen, K. & Ward, S. (2018). Cutting edge strategies to improve executive function skills, presented at Autism Community Training, May 2018, Surrey, BC: published online by ACT. https://www.actcommunity.ca/wp-content/uploads/2018/04/Handout-on-Executive-Function-Skills-Final-Compressed.pdf

Karhu, A., Narhi, V. & Savolainen, H. (2018). Inclusion of pupils with ADHD symptoms in mainstream classes with PBS. *International Journal of Inclusive Education, 22*(5), 475-489.

Kauffman, J. M., Landrum, T. J., Mock, D. R., Sayeski, B., & Sayeski, K. L. (2005). Diverse knowledge and skills require a diversity of instructional groups: A position statement. *Remedial and Special Education, 26*, 2-6.

Kim, P., Evans, G. W., Angstadt, M., Ho, S., Sripada, C. S., Swain, J. E., Liberzon, I, & Phane, K. L. (2013). Effects of childhood poverty and chronic stress on emotion regulatory brain function in adulthood. *Proceedings of the National Academy of Sciences: Early Edition. 110* (46), 18442-18447.

Kolb, D. (1984). *Experiential Learning: Experience as the Source of Learning and Development.* Upper Saddle River, N.J.: Prentice Hall.

Kozik, P. L., Cooney, B. Vinciguerra, S., Gradel, K., & Black, J. (2009). Promoting inclusion in secondary schools through appreciative inquiry. *American Secondary Education, 13*(1), 77–91.

Kumpulainen, K., Kajamaa, A. & Rajala, A. (2018). Understanding educational change: Agency-structure dynamics in a novel design and making environment. *Digital Education Review, 33*(1), 26-38.

Kuntz, E.M. & Carter, E.W. (2019). Review of interventions supporting secondary students with intellectual disability in general education classes. *Research and Practice for persons with severe disabilities, 44*(2), 103-121.

Lansdown, R., Burnell, A. & Allen, M. (2007). Is it that they won't do it or is it that they can't?: Executive functioning and children who have been fostered and adopted. *Adoption and Fostering, 31*(2), 44- 53.

Lee, S. H., Wehmeyer, M. L., Soukup, J., & Palmer, S. B. (2010). Impact of curriculum modifications on access to the general education curriculum for students with disabilities. *Exceptional Children, 76*(2), 213-233.

Lourenco, G. F., Goncalves, A. G., & Elias, N. C. (2015). Differentiated Instructional Strategies and Assistive Technology in Brazil: Are We Talking about the Same Subject? *Universal Journal of Educational Research, 3*(11), 891-896.

Lyons, W.E., Thompson, A. & Timmons, V. (2016). 'We are inclusive. We are a team. Let's just do it': commitment, collective efficacy, and agency in four inclusive schools. *International Journal of Inclusive Education, 20*(8), 889-907.

Magiera, K, & Zigmond, N. (2005) Co-teaching in middle school classrooms under routine conditions: Does the instructional experience differ for students with disabilities in co-taught and solo-taught classes? *Learning Disabilities Research & Practice, 20*(2), 79-85.

Marmolejo, E. K., Wilder, D. A., & Bradley, L. (2004). A preliminary analysis of the effects of response cards on student performance and participation in an upper division university course. *Journal of Applied Behavior Analysis, 37,* 405-410.

Mason, L. H., Cramer, A. M., Garwood, J. D., Varghese, C., Hamm, J., Murray, A. (2017). Efficacy of self-regulated strategy development instruction for developing writers with and without disabilities in rural schools: A randomized controlled trial. *Rural Special Education Quarterly, 36,* 168–179.

Mastropieri, M.A. & Scruggs, T. (2001). Promoting inclusion in secondary classrooms. *Learning Disability Quarterly, 24*, 265-274.

Mastropieri, M. A., Scruggs, T. E., Graetz, J., Norland, J., Gardizi, W. & McDuffie, K. (2005) 'Case studies in co-teaching in the content areas: successes, failures, and challenges'. *Intervention in School and Clinic, 40*(5), 260–270.

Mastropieri, M. A., Scruggs, T. E., Norland, J. J., Berkeley, S., McDuffie, K., Tornquist, E. H., & Connors, N. (2006). Differentiated curriculum enhancement in inclusive middle school science: Effects on classroom and high-stakes tests. T*he Journal of Special Education, 40,* 130 –137.

Mayan, M. (2009). *Essentials of Qualitative Inquiry*. Walnut Creek, CA: Left Coast Press.

McAllum, R. (2014). Reciprocal teaching: Critical reflection on practice. *Kairaranga, 15*(1), 26-35.

McKinney, S., & Frazier, W. (2008). Embracing the principles and standards for school mathematics: an inquiry into the pedagogical and instructional practices of mathematics teachers in high-poverty middle schools. *Clearing House, 81*, 201-210.

Meltzer, L. (2010). *Promoting Executive Function in the Classroom.* New York, NY: The Guilford Press.

Meltzer, L. & Krishnan. (2007). Executive function difficulties and learning disabilities: Understandings and misunderstandings. In L. Meltzer (Ed.), *Executive Function in Education: From theory to practice* (pp. 77-105). New York, NY: The Guilford Press.

Meltzer, L., Pollica, L. S. & Barzillai. (2007). Executive function in the classroom: Embedding strategy instruction into daily teaching practices. In L. Meltzer (Ed.), *Executive Function* *in Education: From theory to practice* (pp. 165-193). New York, NY: The Guilford Press.

Meyer, A., Rose, D.H. & Gordon, D. (2016). *Universal Design for Learning: Theory and Practice.* Wakefield, MA: CAST Professional Publishing.

Montague, M., Enders, C., & Dietz, S. (2011). Effects of cognitive strategy instruction on math problem solving of middle school students with learning disabilities. *Learning Disability Quarterly, 34*, 262–272.

Moore, S. (2016). *One without the Other: Stories of Unity Through Diversity and Inclusion.* Winnipeg, MB: Portage and Main Press.

Moore, S. (2019, January 15). *Templates.* Blogsomemore. https://blogsomemoore.com/shout-outs/templates/.

Moore, S. (2018, Oct, 15). *Inclusive Classroom Strategies and the New Curriculum.* [Transforming Inclusive Education Professional Development Series #1]. Teacher Professional Development, Courtenay, BC, Canada.

Moore, S (2019, Jan. 14). *Inclusive Classroom Strategies and the New Curriculum.* [Transforming Inclusive Education Professional Development Series #2]. Teacher Professional Development, Courtenay, BC, Canada.

Moore, S (2019, Mar. 4). *Inclusive Classroom Strategies and the New Curriculum.* [Transforming Inclusive Education Professional Development Series #3]. Teacher Professional Development, Courtenay, BC, Canada.

Morningstar, M.E., Shogren, K.A, Lee, H, & Born, K. (2015). Preliminary lessons about supporting participation and learning in inclusive settings. *Research and Practice for Persons with Severe Disabilities, 40*(3), 192-210.

Mulcahy, C.A., Maccini, P.M., Wright, K. & Miller, J. (2014). An examination of intervention research with secondary students with EBD in light of common core state standards for mathematics. *Behavioral Disorders, 39*(3), 146-164.

Ness, M. (2007). Increasing the inclusion of reading comprehension strategies in secondary content-area classrooms. *The Language and Literacy Spectrum, 17,* 3-13

Nigg, J. T. & Casey, B. J. (2005). An integrative theory of attention-deficit/ hyperactivity disorder based on the cognitive and affective neurosciences. *Development and Psychopathology, 17*(3), 785-806.

Ohtake, Y. (2003). Increasing class membership of students with severe disabilities to contribution to classmates' learning. *Research & Practice for Persons with Severe Disabilities, 28*(4), 228-231.

Ozonoff, S. & Schetter, P. L. (2007). Executive dysfunction in autism spectrum disorders: From research to practice. In L. Meltzer (Ed.), *Executive Function in Education: From theory to practice* (pp.133-160). New York, NY: The Guilford Press.

Pennington, B.F. (1991). Attention deficit hyperactivity disorder. In B.F. Pennington (Ed.), *Diagnosing learning disorders: A neuropsychological framework* (pp. 82-110). New York: Guilford Press.

Rappolt-Schlichtmann, G., Daley, S. G., Lim, S., Lapinski, S., Robinson, K. H., & Johnson, M. (2013). Universal design for learning and elementary school science: Exploring the efficacy, use, and perceptions of a web-based science notebook. *Journal of Educational Psychology, 105*, 1210- 1225.

Robinson, S., Goddard, L., Dritschel, B., Wisley, M., & Howlin P. (2009). Executive functions in children with autism spectrum disorders. *Brain and Cognition, 71*(3), 362–368.

Rose, D. & Rose, K. (2007). Deficits in executive function processes. In L. Meltzer (Ed.), *Executive Function in Education: From theory to practice* (pp. 287-320). New York, NY: The Guilford Press.

Rosenshine, B., & Meister, C. (1994). Reciprocal teaching: A Review of the research. *Review of Educational Research, 64*(4), 479–530.

Roy, A., Guay, F. & Valiois. (2013). Teaching to address diverse learning needs: development and validation of a Differentiated Instruction Scale. *International Journal of Inclusive Education, 17*(11), 1186-1204.

Ryndak, D. L., & Billingsley, F. (2004). Access to the general education curriculum. In C. H. Kennedy & E. Horn (Eds.), *Including students with severe disabilities* (pp. 55-56). Boston: Allyn & Beacon.

Salend, S. J., & Duhaney, L. M. (2011). Historical and philosophical changes in the education of students with exceptionalities. *Advances in Special Education, 21*, 1-20.

Samuels, W. E., Tournaki, N., Blackman, S. & Zilinski, C. (2016). Executive functioning predicts academic achievement in middle school: A four-year longitudinal study, *The Journal of Educational Research, 109*(5), 478-490.

Schwab, J.R., Tucci, S. & Jolivette, K. (2013). Integrating schema-based instruction and response cards for students with learning disabilities and challenging behaviours. *Beyond Behaviors, 22*(3), 24-30.

Schmidt, R.J., Rozendal, M.S. & Greenman, G.G. (2002). Reading instruction in the inclusion classroom: Research-based practices. *Remedial and Special Education, 23*(3), 130-140.

Schnellert, L.M., Butler, D.L., & Higginson, S.K. (2008). Co-constructors of data, co-constructors of meaning: Teacher professional development in an age of accountability. *Teaching and Teacher Education, 24*, 725-750.

Sebba, J., and M. Ainscow. (1996). International Developments in Inclusive Schooling: Mapping the Issues. *Cambridge Journal of Education, 26* (1), 5–18.

Sen, B. & Ford, N. (2009). Developing reflective practice in LIS education: The SEA-change model of reflection. *Education for Information, 27*(4), 181-195.

Somerville, D & Keeling, J. (2004). A practical approach to promote reflective practice within nursing. *Nursing Times*, 100(12), 42-45.

Sorensen, E. K., & Andersen, H. V. (2017). Strengthening inclusion of learners with attention difficulties through interventions with digital technology in processes of production. *European Journal of Open, Distance and E-Learning (EURODL), 20*(1), 45-60.

Spaulding, L.S & Flannagan, J.S. (2012). DIS2ECT: A framework for effective inclusive science instruction. *Teaching Exceptional Children, 44*(6), 6-14.

Spooner, F., Baker, J. N., Harris, A. A., Ahlgrim-Delzell, L., & Browder, D. M. (2007). Effects of training in universal design learning on lesson plan development. Remedial and Special Education, 28, 108-116.Spradley, J. P. (1979). *The ethnographic interview.* Long Grove, IL: Waveland.

Stein, J. A. & Krishnan, K. (2007). Nonverbal learning disabilities and executive function: The challenges of executive assessment and teaching. In L. Meltzer (Ed.), *Executive Function in Education: From theory to practice* (pp. 106-132). New York, NY: The Guilford Press.

Terzi, L. (2014). Reframing inclusive education: educational equality as capability equality. *Cambridge Journal of Education, 44*(4), 497-493.

Thompson, S. (1997). *The Source for Nonverbal Learning Disorders.* East Moline, IL: LinguiSystems.

Thompson, N., & Pascal, J. (2012). Developing critically reflective practice. *Reflective Practice, 13*(2), 311-325.

Thorell, L., Lindqvist, S., & Nutley, S, B. (2009). Training and transfer effects of executive functions in preschool children. *Developmental Science, 12*(1), 106-113.

Tremblay, P. (2013). Comparative outcomes of two instructional models for students with learning disabilities: inclusion with co-teaching and solo-taught special education. *Journal of Research in Special Educational Needs, 13*(4), 251-258.

Trussell, R.P, Lewis, T.J. & Raynor, C. (2016). The impact of Universal Teacher Practices and Functional Behaviour Interventions on the rates of problem behaviours among at-risk students. *Education and Treatment of Children, 39*(3), 261-282.

Waber, D., Gerber, E. B., Turcios, V., Wagner, E. R., & Forbes, P. W. (2006). Executive functions and performance on high-stakes testing in children from urban schools. *Developmental Neuropsychology, 29*(3), 459–477.

Waitoller, F. R. & Artiles, A. (2013). A decade of professional development research for inclusive education: A critical review and notes for a research program. *Review of Educational Research, 83*(3), 319-356.

Watt, S.J, Therrrien, W.J., Kaldenberg, E. & Taylor, J. (2013). Promoting inclusive practice in inquiry-based science classrooms. *Teaching Exceptional Children, 45*(4), 40-48.

Wehmeyer, M. L. (2014). Disability in the 21st century: Seeking a future of equity and full participation. In M. Agran, F. Brown, C. Hughes, C. Quirk, & D. Ryndak (Eds.), *Equity and full participation for individuals with severe disabilities: A vision for the future* (pp. 3-23). Baltimore, MD: Paul H. Brookes.

Wehmeyer, M., Yeager, D., Bolding, N., Agran, M. & Huges, C. (2003). The effects of self-regulation strategies on goal attainment for students with developmental disabilities in general education classes. *Journal of Developmental and Physical Disabilities, 15*(1), 79-91.

Wood, L., Browder, D.M. & Flynn, L. (2015). Teaching students with intellectual disability to use a self-questioning strategy to comprehend social studies text for an inclusive setting. *Research and Practice for Persons with Severe Disabilities, 40*(4), 275-293.

Worrell, J. (2008). How secondary schools can avoid the seven deadly "sins" of inclusion. American Secondary Education, 36(2), 43-56.

Young, K. & Luttenegger, K. (2014). Planning "lessons for everybody" in secondary classrooms. *American Secondary Education, 43*(1), 25-32.

Zhang, M., Trussell, R.P., Gallegos, B. & Asam, R.R. (2015). Using math apps for improving student learning: *An exploratory study in an inclusive fourth grade classroom. TechTrends, 59*(2), 32-39.