Project-Based Learning in Mathematics: A Middle School Curriculum Unit

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Submitted in partial fulfillment of the requirements for the degree of Master of Education

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Abstract
The purpose of this study was to develop a mathematics-focused project-based learning curriculum unit for educators to utilize with their own classes. Based on literature review and resources, an integrated unit was created using a backwards design method of curriculum development, with the intent of assisting teachers who are unfamiliar with the principles of project-based learning. The unit covered grade 7 Ontario Ministry of Education expectations from the mathematics, science, and language curriculums and also aided in students’ development of several 21st century competencies including effective communication, collaboration, and problem solving. The unit was created to act as a guide for educators to assist them in learning how to implement project-based learning effectively, so as to make learning meaningful, relevant, and enjoyable for students.
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CHAPTER ONE: THE PROBLEM

When taught through traditional methods of teaching, many students struggle to find mathematics relevant and meaningful to their own lives (Uyangor, 2012). As a result, students may feel it is a boring and unnecessary subject. To combat these views, teachers must engage students of all ages in mathematics lessons that are engaging, enjoyable, and meaningful to students. One teaching method that can be used to accomplish this is called project-based learning (PBL). PBL is a student-centred learning approach in which students develop content knowledge and 21st century skills through self-directed projects (Bell, 2010).

This project aims to provide educators with an integrated, mathematics-focused curriculum unit that uses the principles of PBL. Following the expectations of the Ontario curriculum, this unit plan covers expectations from the grade 7 mathematics, science, and language curricula. Through PBL, these lessons engage students with mathematics and make the concepts relevant and meaningful.

Background of the Problem

Mathematics is a subject that students often find abstract and, therefore, they may struggle to find its relevancy in their own lives (Uyangor, 2012). Traditionally, mathematics has often been taught through textbook questions, quizzes, and tests, which are not generally engaging activities for students (Larmer & Mergendoller, 2010). Instead of these traditional means of mathematics education that focus on content knowledge, the focus has shifted towards the process skills of mathematics and being able to apply mathematical concepts in real-world scenarios (Ontario Ministry of Education, 2005). This can be seen in the current Ontario mathematics curriculum document, which stresses
the importance of developing students’ mathematics process skills in every grade (Ontario Ministry of Education, 2005). It is clear that the goal of mathematics education is not just on content knowledge, but also on the skills that underpin the mathematics process including problem solving, communication, critical thinking, and inquiry.

The challenge for educators is how to teach mathematics content knowledge and the accompanying mathematics process skills in a manner that students will find engaging and relatable, and PBL is one approach that can be used to accomplish this. PBL’s student-centred approach allows students to take control of their learning and it has a key focus on integrating the development of content knowledge and 21st century skills such as collaboration, problem solving, critical thinking, inquiry, and communication (Larmer & Mergendoller, 2012). Additionally, PBL’s focus on real-world problems and real audiences lends itself to making clear connections between mathematics and the lives of students.

However, one of the main problems with implementing PBL is that there has been some confusion surrounding the definition of PBL and specifically, how PBL differs from traditional school projects (Larmer & Mergendoller, 2010). PBL has several key features that differentiate it from simple classroom projects, which is not always clear to educators wanting to use PBL in their classrooms.

**Purpose of the Project**

The purpose of this project was not only to learn more about PBL and its potential applications in mathematics, but also to design an integrated, mathematics-focused curriculum unit that used the principles of PBL to make mathematics interesting and relatable to students. This curriculum unit is intended to teach the concepts and the
process skills of mathematics while also increasing students’ enjoyment of mathematics. Using PBL to create connections between mathematics concepts and the real world was intended to make mathematics more relevant and meaningful to the students. As is common in PBL, although the focus of this unit is mathematics, other subjects, including science and language, have been integrated throughout.

This curriculum unit was also designed to provide other teachers with a practical guide of how PBL can be used to teach mathematics to intermediate students. This project is meant to assist teachers who may not have used PBL before and to provide them with practical lessons that demonstrate how a PBL unit can be implemented in their own mathematics classes to teach the Ontario curriculum.

**Importance of the Project**

The completion of this project is of particular importance to myself as a mathematics educator as it further developed my understanding of various effective teaching practices and educational approaches. This project allowed me to reflect on how PBL can be incorporated into my own teaching and how best to implement the key features of PBL into a mathematics unit. Because of the student-centred approach of PBL, the development of this unit required me to consider the students’ perspectives throughout the project and adjust the freedom of the unit accordingly.

This unit will also be of importance to other educators who wish to learn more about making mathematics more relatable and enjoyable for their students through PBL. Teachers unfamiliar with PBL may choose to use this unit as it is presented, especially teachers of intermediate mathematics, since this unit provides detailed lessons using the grade 7 curriculum. Alternatively, teachers may use this curriculum unit as a guide to
deepen their understanding of how they can incorporate PBL into other grades and other subject areas. However teachers choose to use this unit, this project will play an important role in assisting those teachers develop their own understanding of using PBL effectively.

Finally, this project is important for the students who get the opportunity to learn through PBL as a result of this curriculum unit. Learning about mathematics in an enjoyable and relatable manner is important for students and assists in developing positive attitudes towards learning. The 21st century skills that students develop through PBL are transferable skills that they will be able to apply to future academic pursuits and in their daily lives.
CHAPTER TWO: REVIEW OF THE LITERATURE

PBL is a learner-centred instructional strategy that integrates the learning of subject knowledge with 21st century skill development (Bell, 2010). Distinct from traditional school projects, PBL engages students with self-directed, in-depth investigations of real-world problems that are relevant and meaningful to the lives of students (Larmer & Mergendoller, 2012). While PBL often integrates several subjects together within a single project, the purpose of this paper is to investigate how PBL is being used in an integrated mathematics context. Understanding the key features of PBL, along with strategies for effective implementation into mathematics classes, is important for educators who are attempting to utilize this instructional strategy in their own classes. The following will explore the defining features of PBL, the benefits associated with PBL, how PBL is currently being used in a mathematics context, and, finally, it will discuss the planning required to ensure effective implementation of PBL in an integrated mathematics context.

Defining Project-Based Learning

A common misconception about PBL is that it is equivalent to traditional classroom projects, which is not the case (Larmer & Mergendollar, 2010). Traditionally, a subject-based unit is taught through lectures, textbook readings, worksheets, and similar passive activities, and as the unit is nearing completion the students are assigned a project. Often, these are individual projects that require restating the information that was learned throughout the unit. Students may be required to summarize information in a pamphlet, a poster, or a speech. Projects are then collected and other than a potential short presentation to peers, the projects are not generally discussed in depth (Larmer & Mergendollar, 2010). These kinds of projects act as add-ons to the unit and focus on
consolidating learning; they are projects, but they are not examples of PBL.

Conversely, in PBL, the project is the driving force for the entire unit of study. Drawing on constructivism, constructionism, and the teachings of John Dewey, PBL engages students with complex, real-world projects that teach significant subject content and require the use of a variety of 21st century skills (Grant, 2002). While there is some debate over the official definition of PBL and the necessary features (Yetkiner, Anderoglu & Capraro, 2008; Zafirov, 2013), Buck Institute for Education (BIE; n.d.), a leader in PBL research and information, defines PBL as “a teaching method in which students gain knowledge and skills by working for an extended period of time to investigate and respond to a complex question, problem, or challenge.” Further, Larmer and Mergendoller (2012) of the Buck Institute for Education state that there are eight key features of PBL; significant content, a need to know, a driving question, student voice and choice, 21st century competencies, in-depth inquiry, critique and revision, and a public audience.

**Significant Content**

PBL, when planned effectively, can be used to teach significant amounts of content from several subjects. The projects that students complete are not supplementary activities, rather, the project is the basis of all learning in the chosen unit of study (Bell, 2010). As with the planning of any educational activity, teachers who are planning PBL projects must consult curriculum expectations and ensure the project meets the expectations. Despite accusations that the time restraints of PBL limit the amount of information covered, in reality PBL requires students to have a very in-depth understanding of the content of the unit (Larmer & Mergendoller, 2012).
A Need to Know

The projects that students work on in PBL classes should be engaging and motivating enough that students feel a need to know more about the project topic. Student engagement is paramount in PBL and can be tapped into during an introductory activity when introducing the topic of the project in an interesting manner (Grant, 2002). Engaging students with the project is crucial because PBL requires students to be self-directed learners and, therefore, they need to be self-motivated and must self-regulate their work habits (English & Kitsantas, 2013). Students are motivated because they need to learn the information because it is needed to complete a project that they have chosen and accepted, rather than because it will appear on the test, as is often the case in traditional classroom settings (Larmer & Mergendoller, 2010).

Driving Question

A driving question is a crucial aspect of the PBL process because it defines the purpose of the project and clearly identifies what the project will focus on (Larmer & Mergendoller, 2010). Good driving questions are complex, open-ended problems that do not have one clear or correct answer (English & Kitsantas, 2013). The driving question (a) helps students understand what they are trying to accomplish, (b) gives a context to what they are learning, and importantly (c) helps to highlight why they are learning about a topic. Driving questions can be created by the teacher, co-created by the class, or can be unique to each group.

Student Voice and Choice

PBL is a student-centred instructional strategy and, as such, gives students significantly more voice and choice in their learning than would be done in a traditional
project. Giving students choices about the project allows them to take responsibility for the project and helps to make the learning more meaningful and relevant to their lives (Larmer & Mergendoller, 2012). When students have input about what they are learning, how they are learning it, and how they demonstrate their learning, they are more likely to find the learning meaningful and enjoyable (Bell, 2010). The amount of voice and choice given to students will vary according to the comfort level of the teacher and the readiness of the students (Larmer & Mergendoller, 2010; Park-Rogers, Cross, Sommerfeld-Gresalfi, Trauth-Nare, & Buck, 2010).

**21st Century Competencies**

The learning goals of PBL extend beyond simply acquiring content knowledge; they require students to develop a variety of 21st century skills including problem solving, critical thinking, communication, inquiry, creative innovation, collaboration, and higher level thinking skills (Bell, 2010; Larmer & Mergendoller, 2012). These are transferable skills required to be successful in the 21st century in school, in work, and in the community. The 21st century skills developed during PBL are skills that students can continue to develop throughout their educational careers and that can be applied in a variety of real-world contexts. Teachers of PBL need to explicitly teach and assess these 21st century skills since these skills are required to successfully complete PBL projects (Buck Institute for Education, n.d.).

**In-Depth Inquiry**

In-depth inquiry goes beyond simply reading a textbook or doing a quick internet search to find the answer to a closed-ended problem. In-depth inquiry is a process by which students form their own questions and actively seek out complex answers from a
variety of information sources (Larmer & Mergendoller, 2010). Students can investigate their chosen project through traditional means, such as books and websites, but can also gain valuable and real-world knowledge by contacting experts in the field through email or video-conferencing (Hopper, 2014). In-depth inquiry in PBL is an ongoing process of questioning, researching, testing ideas, identifying new questions, and drawing their own conclusions (Larmer & Mergendoller, 2012). Active engagement in this kind of authentic and purposeful investigation allows the learning to be relevant and meaningful to the lives of students (Grant, 2002).

**Critique and Revision**

In PBL classes, the teacher is to act as a guide for students throughout the process, and should provide ongoing opportunities for critiques and feedback on students’ progress and products (Buck Institute for Education, n.d.). Students will engage in an ongoing process of creation and revision to ensure high-quality project products (Larmer & Mergendoller, 2012). To make feedback more meaningful and relevant, the teacher may bring in experts and adult mentors to provide feedback as well.

**Public Audience**

Presenting the final product of a project to a public audience helps students take ownership over their work and helps them strive to produce high quality products (Larmer & Mergendoller, 2012). Instead of presenting their work to classmates and their own teacher, students in PBL classes present to a relevant public audience which adds to the authenticity of the project. Depending on the content and purpose of the project, example audiences may include school administration, local governments, or a group of community members who are familiar with the topic.
It is important to note that although beneficial, it may not always be possible to find a relevant public audience for the project presentations. However, attempts should be made to showcase projects in some public manner, such as posting them online where they are accessible to a larger audience. Further, not all descriptions of PBL require a public audience and instead suggest simply presenting to other classes and teachers is sufficient (Bell, 2010), although most agree that a public audience is preferred whenever possible.

**Benefits Associated with PBL**

Understanding the defining features of PBL provide insight into the benefits associated with learning through this type of instructional strategy. Current research has found a number of benefits associated with PBL ranging from increased student motivation and academic achievement, to making education more equitable for a diverse group of learners.

**Increased Academic Achievement**

When students engage with PBL, research has found that they experience increases in their academic achievement across a range of subjects and grades (Kaldi, Filippatou, & Govaris, 2011; Karacalli & Korur, 2014; Uyangor, 2012; Yetkiner et al., 2008). For instance, a 2011 study by Kaldi et al. studied a group of grade 4 students as they completed a PBL unit on sea-animals. Through a pre- and post- test of content knowledge and individual interviews, they found that students’ content knowledge improved after participating in the PBL unit (Kaldi et al., 2011). However, without a control group, it is not clear whether or not students would have experienced a similar increase in knowledge through traditional means of instruction, such as direct instruction, or if the findings were
a result of learning the information through PBL.

Similarly, Karacalli and Korur (2014) also examined the effects of PBL on fourth grade students’ academic achievement and retention of knowledge. Using pre- and post-tests, a control group that learned through traditional means, and an experimental group that used PBL, it was found that the students that engaged in PBL showed significantly higher gains in their academic achievement by the end of the unit than the control group. The students that learned through PBL also retained the information much better over a period of time than the students who learned through more traditional means (Karacalli & Korur, 2014). The presence of a control group that learned through traditional instructional strategies strongly suggests that the increases in academic achievement can be attributed to engaging in PBL.

**Improved Motivation and Attitude Towards Learning**

Although there have been some mixed results, another researched benefit of PBL is that students demonstrate increased motivation and better attitudes towards learning after experiencing PBL (Grant, 2002; Kaldi et al., 2011; Karacalli & Korur, 2014; Selmer, Rye, Malone, Fernandez, & Trebino, 2014). A 2011 study used both attitude rating scales and individual interviews to find that students who learned through PBL had increased attitudes towards learning and towards group work (Kaldi et al., 2011). Further, this study also found that students self-reported increased motivation after engaging in a PBL unit.

Considering the student-centred approach of PBL, increased motivation and attitudes towards learning are not surprising side-effects. Giving students choice over a project topic and engaging them with real-world problems and solutions makes learning more enjoyable for students and, thus, motivates them to learn more (Grant, 2002).
Learning in PBL has a clear purpose and is relevant to students’ lives and is, therefore, much more engaging and enjoyable than traditional classwork that students often find boring and meaningless (Larmer & Mergendoller, 2010). Further, participating in group assignments is often motivating for students because they do not want to let their group members down (Bell, 2010).

Interestingly, a study conducted by Karacalli and Korur (2014) did not find that students in PBL settings showed a difference in attitude, which they attributed to the fact that the unit was relatively short-lived and lasted only a few weeks. The authors speculated that if students were to engage in PBL for an extended amount of time, they would experience a change in attitude.

**Development of 21st Century Skills**

One of the key goals of PBL is to help students develop 21st century skills as well as acquiring content knowledge. As was previously mentioned, 21st century skills are skills that are required to be successful in school, in the workplace, and in the community in the 21st century (Larmer & Mergendoller, 2012). These skills include communication, collaboration, critical thinking, creativity, problem solving, and inquiry (Bell, 2010; Larmer & Mergendollar, 2012). PBL requires students to develop all of these skills to be successful. Collaboration is fostered through working with a team, while problem solving is a natural consequence of engaging students with the task of finding solutions to real-world problems (Bell, 2010). Presenting products and communicating with peers and educators develops communication skills, while organizing ideas into logical and purposeful products requires the use of critical thinking and creativity. These are important skills that need to be fostered in students, and PBL is a meaningful way for
students to develop several of these kinds of skills in a single assignment (Bell, 2010).

Creation of Equitable Learning Experiences

Another benefit associated with PBL is that it can help make education more equitable for a diverse group of students. Research has shown that students of certain ethnicities and socioeconomic backgrounds often experience lower levels of achievement in schools than others, but PBL can be used to decrease and eliminate these discrepancies (Boaler, 2002; Cross et al., 2012).

For instance, a study by Boaler (2002) examined two schools, one of which used reform curriculum (PBL) and another that used traditional methods, and found that the students at the school using reform curriculum attained significantly higher grades on several assessments of mathematics achievement. Further, the traditional school found that 80% of students achieving above grade level were from middle-class families, while 80% of those achieving below grade level were from lower, working-class families. Conversely, at the project-based school, underachievers and overachievers were equally distributed between middle and working-class students. Also, the traditional school found that boys had significantly higher mathematics grades than girls, while at the project-based school such gender differences did not exist (Boaler, 2002). PBL can, therefore, be used to decrease and eliminate the discrepancies in academic achievement that are often found between socioeconomic classes and between genders.

Similarly, Cross et al. (2012) studied a group of African American girls in grades 4-6 as they engaged in PBL. The goal of the study was to use a PBL approach to teach mathematics in a way that was equitable for this particular group of students. Cross et al. examined how the four pillars of equitable schooling (power, access, identity, and
achievement) were present in this PBL mathematics unit. Using this approach, students found mathematics enjoyable and relatable, and they demonstrated increases in their understanding of statistical concepts and procedures (Cross et al., 2012). These findings were significant because they demonstrated the possibility of using PBL to create learning experiences that were meaningful and relevant to a particular group of students.

**Benefits of PBL in Mathematics**

As has been outlined above, PBL has been found to have a number of benefits for students in different subjects and grades. However, the effectiveness of PBL as an instructional strategy for mathematics has not been examined to the same extent that it has been in other subjects, such as history or science (Halvercheid, 2005; Wood & Chapman, 2004). It is important to note here that PBL projects are nearly always multidisciplinary and, therefore, draw on several subjects. While mathematics may be a subject that is integrated into many projects, it generally has not been examined as the main focus of the unit (Halvercheid, 2005; Wood & Chapman, 2004). However, there are still several studies that have found important benefits of using PBL in a mathematics context, including making mathematics relevant to students, increasing mathematics achievement scores, and improving self-regulation in mathematics (Meyer, Turner, & Spencer, 1997; Uyangor, 2012).

**Makes Mathematics Relevant and Engaging**

While PBL has been found to increase student engagement in several subjects, this is an especially important feature of PBL for mathematics classes. Through traditional means, students may struggle to find mathematics relevant and meaningful to their own lives, and mathematics can be viewed by students to be boring and unnecessary.
(Uyangor, 2012). For these reasons, PBL can be extremely beneficial in a mathematics context. On top of the research of PBL’s ability to engage students, there is also research that has specifically examined how PBL engages students with mathematics content. For instance, a pre- and post-test of attitudes towards mathematics conducted by Uyangor found significant increases in high school students’ self-reported attitudes towards mathematics learning. Key features of PBL, including collaborative learning, engaging with challenging real-world problems, and having choice over the assignment, were cited to be factors that contributed to the students’ positive attitudes towards this style of mathematics learning (Uyangor, 2012). Similarly, Selmer et al. (2014) examined upper elementary students as they engaged in a PBL mathematics unit and it was found that the authentic nature of the project was highly engaging and enjoyable to students. PBL allows students to understand how mathematics is relevant in the real-world and how they can use mathematics to solve actual problems in their own lives, thus making mathematics highly engaging and relevant for students (Selmer et al., 2014).

**Increased Mathematics Achievement**

Improved academic achievement has been cited as a benefit of PBL across subjects, but is also highly relevant in a mathematics context. For instance, Cross et al. (2012) found that upper elementary students’ understanding of mathematical and statistical concepts and procedures increased after participating in project-based mathematics. Similar results were found by Uyangor (2012) who found significant differences between pre- and post-tests of high school students’ mathematics achievement as a result of engaging with project-based mathematics. Overall, when considering mathematics performance on standardized and high-stakes tests, the academic performance of students
who engaged with PBL is significantly greater than the students who did not engage with PBL mathematics.

**Effective Implementation of PBL in Mathematics**

While there are many researched benefits associated with PBL and with using it specifically in a mathematics context, there is also a significant amount of planning that needs to be done by the teacher if PBL is to be implemented into mathematics classes effectively to achieve these benefits. Necessary planning and preparation for the effective implementation of project-based mathematics includes obtaining the necessary technology to support PBL, making contact with appropriate community members, finding a balance between teaching and guiding students, participating in the necessary professional development, and adequately preparing students to make the transition into this unique way of learning.

**Use of Technology**

As is the case with most learning that occurs in the 21st century, technology is used to further students’ understanding and application of academic concepts. This is especially true in PBL in mathematics because there are so many beneficial ways to utilize technology to complete the various stages of PBL. For instance, Zafirov identified several different forms of technology and computer programs that can be used throughout the different stages of PBL. The wide variety of technology that students have access to allows them to dig deeper into their chosen project topic, to further their research, to seek the help of experts, to develop creative products, and to further develop their communication skills and problem-solving skills. Zafirov (2013) discussed several forms of technology that could be used in PBL to develop communication skills and
collaboration including Wikis, blogs, Google Docs, and learning management systems. Further, contributing to and evaluating the information found on many of these sources would require students to critically analyze information, thus developing critical thinking skills (Zafirov, 2013).

Another form of technology that teachers may want to consider incorporating into their PBL classrooms is the use of videoconferencing, since its use in elementary schools has been found to have a number of benefits in PBL. Hopper (2014) studied the example of a Texas elementary school that implemented videoconferencing and PBL learning into every grade; kindergarten to grade 8. Videoconferencing allowed students to investigate “global projects” in which they utilized videoconferencing to explore their topics with partner classes around the world. This method of learning was found to be highly engaging for students and it also assisted in the development of critical thinking skills, problem-solving abilities, and collaboration skills (Hopper, 2014).

Having access to a wide variety of technologies is clearly important in PBL; therefore, teachers need to ensure they provide students with the hardware and software necessary to achieve these goals. One strategy for bringing technology into PBL classes is to introduce digital backpacks. Basham, Perry, and Meyer (2011) explained that digital backpacks are actual backpacks filled with technology to assist students in PBL. Technology included in the backpack may include laptops, camcorders, cameras and tablets loaded with programs and applications specifically chosen to assist with the assigned projects. The incorporation of technology is highly engaging for students and could be used to benefit all learners of all abilities (Basham et al., 2011). Importantly, the programs loaded onto the technology (a) would allow for multiple means of representing
data, (b) would provide several options for representing students’ thinking, and (c) could provide multiple methods of engaging students with the task. In accordance with the principles of Universal Design, these aspects are beneficial for all students, but would be especially useful for students with disabilities, exceptionalities, and students who require any kind of accommodations or modifications.

A further example of technology use in PBL that is directly lined with mathematics expectations is the possible use of virtual manipulatives. A study conducted by Cakiroglu (2014) explored the use of virtual manipulatives in mathematics PBL classes and compared two grade 9 classes, both taught by the same teacher. Both classes used PBL but only one of the classes used virtual manipulatives throughout their projects. It was found that the class using the virtual manipulatives had significantly higher academic gains than the control group, as was assessed by an achievement test (Cakiroglu, 2014).

While there are many promising uses for technology within a PBL classroom, there is always a cost associated with obtaining and maintaining the technology that teachers must consider and plan for. The original digital backpack project partnered with Apple (Basham et al., 2011), which explains how they were able to obtain all of the technology needed to equip the backpacks. However, most schools do not have the means to obtain such large amounts of technology to outfit each class. Instead of equipping each class with backpacks full of technology, simply having the technology in the school and using a sign-out program could work well for most schools. In this situation, all classes would share the technology, thus the school would need to purchase less of it and it would, therefore, be more affordable. Clearly, this is an area that would require planning and budgeting by the teacher, but would also make PBL more effective.
Involving Community Members

As has been discussed previously, part of the reason students find PBL so engaging is its obvious connections to the real-world through the clear applications of knowledge and public presentations (Larmer & Mergendoller, 2012). There are many different forms that a public audience can take when students complete a project. For instance, after completing projects that had students develop statistical literacy to determine what they should grow and subsequently sell at a local farmers’ market, students actually took their produce to a local farmers’ market and attempted to sell it (Selmer et al., 2014). This kind of public audience was enjoyable for students; it motivated them to do well, and it was also a clear way to assess the accuracy of their predictions about what produce would sell best. This kind of final, public presentation required the teacher to plan out where students would “present” and then organize the permissions to ensure the trip to the farmers’ market was possible.

Other public audiences may involve bringing in expert members from the community who are familiar with the topic of a project. For instance, a unit plan created by the Buck Institute for Education (2014) brought in bankers to assist students in learning about what micro-loans are and how they work, and to deepen their understanding of repayment schedules. Students then chose a project from an organization called Kiva to give a $25 microloan to, and created a financial plan for the loan (BIE, 2014). For their final presentations, students presented their presentations to potential investors from the community who were interested in giving micro-loans to some of the proposed projects. Involving community members at several stages of the project made the learning relevant to the real-world and motivated students to produce
high-quality final products. Similarly, a project that had students developing budgets and marketing plans for grocery stores required students to present their business strategy to local business owners and managers for feedback (Snoberger, 2009), while a project that had students create a product, an electronic prototype, and a financial plan for their new company gave students the opportunity to present their pitch to an expert panel of community members (Aguirre & Holcomb, 2005). Involving community members and public audiences are key features of PBL that make it enjoyable, engaging, and relevant for students, but they are also aspects that teachers must actively plan for. Teachers need to consider who might be a useful and relevant audience for the projects that students are completing and then must consider how to approach these people and include them in the project process.

**Teacher Readiness**

A crucial aspect of effectively implementing any new instructional strategy is ensuring that the teachers are accepting of the strategy and that they have the necessary information to execute it properly. The importance of this was demonstrated by a study conducted by Park-Rogers et al. (2010) that followed three educators, each with their own educational beliefs and orientations, through their first year of implementing PBL in mathematics and science classes. It was found that how teachers implement PBL, the adjustments they make, and whether or not they revert to traditional teaching practices were all heavily influenced by the educational orientations the teachers held before implementing PBL. Perhaps not surprisingly, Park-Rogers et al. found that the teachers who saw themselves as facilitators of student learning and who were more focused on the development of 21st century skills than on meeting core content standards were much
more accepting of the PBL philosophy. These educators were also more likely to see the value of PBL and to continue using PBL in their mathematics and science classes. Conversely, one teacher who was content-focused and had previously used traditional, teacher-centred strategies faced many challenges when attempting to implement PBL and actually stopped using PBL part way through the year because it was in too much conflict with the teacher’s beliefs (Park-Rogers et al., 2012).

Similarly, a study by Wood and Chapman (2004) found that the beliefs teachers hold about the purpose of mathematics education and, specifically, how mathematics is learned, will heavily influence how willing they are to implement certain features of PBL. For instance, some of the teachers studied believed that mathematics was traditionally an individual endeavour and, as such, they often had students working on individual projects instead of working collaboratively (Wood & Chapman, 2004). It seems that regardless of what educational orientation a teacher holds, using PBL does not change these beliefs, and teachers will continue to hold the beliefs that they have always held. As such, when PBL conflicts with a teacher’s beliefs about education and learning, PBL will most likely not be an effective teaching strategy.

With this in mind, it is important not to force teachers into using PBL, and if teachers decide they would like to use PBL, then they must be given adequate professional development and training on how to do so effectively. The need for PD concerning how to properly and effectively implement PBL is important because not all educators are aware of the definition of PBL, thus leading to confusion between PBL and traditional classroom projects (Yetkiner et al., 2008; Zafirov, 2013). Effective implementation of PBL will also likely require ongoing support for teachers as they
implement PBL for the first time to answer any ongoing questions and concerns they may have (Snoberger, 2009). Further, considering the interdisciplinary nature of PBL, teachers will also likely need to meet with and collaboratively plan projects with teachers of other subjects (Yetkiner et al., 2008). Clearly, teacher readiness, preparation, and ongoing professional development are necessary for effective implementation of PBL.

**Assisting and Preparing Students**

A final planning consideration to ensure effective implementation of PBL is to adequately prepare students for this new style of learning. Students who are accustomed to traditional passive, teacher-directed learning will need to be supported as they transition into PBL. It is important that teachers consider students’ comfort level with this student-centred approach when deciding how much freedom to afford to students over project options (Larmer & Mergendoller, 2012).

Students’ previous educational experiences, their personality, and their preferred learning style can influence how easily they are able to transition into PBL. English and Kitsantas (2013) found that in order for PBL to be effective, the teacher must first establish a classroom environment that promotes students’ self-regulation. Self-regulation includes a student’s ability to set goals, plan a course of action, and self-monitor and self-evaluate their own learning (English & Kitsantas, 2013). These skills are required to succeed in the self-directed environment of PBL; however, they are not inherent in all students and must be explicitly taught and modelled by the teacher. Having a strong understanding of students’ abilities and readiness for independent learning is necessary for the teacher to adequately plan a project that is within students’ capabilities. Regardless of student readiness, teachers must always provide high levels of guidance
and support through the entire duration of the project (Grant, 2002). Teachers of PBL must constantly strive to balance giving students adequate, challenging levels of choice, while also providing the scaffolding and assistance that students need to be successful (Yetkiner et al., 2008).

Like all instructional practices, PBL is better suited to the learning styles and preferences of some students more so than others. Meyer et al. (1997), found two general subgroups of students in PBL classes, the challenge seekers and the challenge avoiders. Challenge seekers had a high self-reported tolerance for failure; they demonstrated learning-oriented behaviour, and they had a high level of self-efficacy in mathematics (Meyer et al., 1997). Conversely, challenge avoiders self-reported experiencing more negative effects of failure, showed performance-orientated behaviours, and had lower self-efficacy in mathematics. These two types of students worked very differently in a PBL mathematics environment and it was found that PBL was not as effective challenge avoiders as it was for challenge seekers (Meyer et al., 1997).

It is important to note, however, that students with high levels of self-regulatory learning skills are able to set challenging but realistic goals for themselves; they develop purposeful plans of action, and they monitor their own learning along the way (English & Kitsantas, 2013). These skills would have been extremely beneficial for the challenge avoiders in the Meyer et al. (1997) study as much of their difficulty in a PBL environment was related to the goals they had set for themselves (goals that focused on achieving high grade, rather than a deeper level understanding). Interestingly, the openness of PBL gives students the opportunity to pick a project that suits their ability level; however, as was shown by the challenge avoiders, PBL also gives students the
opportunity to choose projects that are well within their ability range and, therefore, does not necessarily challenge students to learn more. This can be problematic since students who set easily attainable goals are not furthering their learning by completing the project. For these reasons, it is extremely important that teachers know at what level students are capable of learning, and that students are taught the self-regulatory skills needed to be successful in a PBL environment prior to transitioning to PBL.

**Conclusion**

PBL is a student-centred, inquiry based instructional strategy that can be used with students in all grades and to teach any combination of subjects. Through PBL, students gain content specific knowledge and develop 21st century skills while identifying and attempting to solve authentic problems that arise from real-world scenarios. PBL has been found to be associated with a variety of student benefits including increased academic achievement and improved motivation and engagement, while also creating more equitable learning experiences for a diverse group of students. Due to its multidisciplinary nature, the benefits of PBL can be extended to all subjects and it shows promise as an effective strategy for teaching mathematics. However, if PBL is to be implemented effectively, teachers need to plan accordingly. Using technology, involving members of the community, having teachers participate in professional development, and perhaps most importantly, preparing students for independent learning, are necessary for PBL to be implemented effectively.
CHAPTER THREE: METHODOLOGY

This unit plan was designed and developed using current methods of curriculum unit design, while the lessons were designed to meet the grade seven expectations of the Ontario mathematics, science, and language curricula. Additionally, project-based learning features were included throughout the unit, including all lesson plans and assessment tools.

**The Process of Unit Development**

This unit plan was designed using the backwards design model of curriculum unit development in which the planning process begins with the end goals. To begin planning, the grade 7 Ontario curriculum documents were consulted and expectations from mathematics, science, and language curricula were chosen. Once it was determined which expectations students would need to learn by the end of the unit, the final assessment task was decided upon and assessment tools were planned. Using backwards design ensured that the final assessment task was directly related to the curriculum expectations chosen for the unit. Beginning planning for the unit by deciding on the end goals allows educators to plan learning activities and lessons that build on each other and prepare students for their final assessment task. Assessment and evaluation tasks were integrated into all lessons and these assessments also prepare students for the final assessment task. In this way, backwards design ensures the lessons, the final task, and the assessment tools are all aligned.

The lessons included in this curriculum unit were designed to meet expectations from the Ontario curriculum. The lessons are presented in a general lesson plan template that many teachers would be familiar with. Each lesson plan includes the curriculum
expectations that are being addressed, a clear description of the lesson/activity with a suggested time frame, a list a necessary materials, assessment opportunities, and suggestions for differentiated instruction. In addition, any worksheets or assessment tools discussed are included at the end of each lesson. A general lesson and assessment overview chart is also provided at the beginning of the unit for quick reference. This chart outlines which curriculum expectations are covered in each lesson, how long each lesson should take, and lists all assessment opportunities in each lesson.

**Project-Based Learning Planning Considerations**

This curriculum unit was designed to teach strands from the Ontario grade 7 mathematics, science, and language curricula using a PBL approach. Because of the student-centred nature of PBL, the lessons included in this unit are more guidelines than set parameters. Incorporating student voice and choice throughout the unit requires flexibility on the part of the teacher to allow students to guide their own learning to a certain extent. Additionally, PBL requires ongoing input from both the teacher and the students, which may lead to adding or removing aspects of the project when it is implemented. As a result of these PBL factors, timelines may differ in reality from the timelines suggested by this unit outline. For the purposes of this project, one period is assumed to be 40 minutes long.

When designing a project-based learning unit, educators must decide how open-ended to make the projects. Teachers may choose to give students free reign over project topics and allow groups to work at their own pace. Alternatively, they may choose to provide some project guidelines to ensure that projects will meet the requirements of the curriculum and that all projects will include specific content or products. In ideal PBL
classes, students will have input during each stage of choosing the project. For the purpose of this project, examples will be provided based on hypothetical discussions between the teacher and the students. For instance, assessment tools and rubrics should be co-constructed with students, so the assessment tools included in this unit are samples. When teachers implement this unit in their own classes, it is likely that their assessment tools will not exactly match the ones provided in this unit, although they should be assessing similar criteria. Clearly, the direction of the project will differ from class to class depending on student interest, as is the nature of PBL.

Lessons in a true PBL class will also be determined in consultation with the students and in accordance to the purpose of the chosen project. Because of this, creating a full, detailed unit outline prior to beginning the projects can be difficult when using PBL. For the purpose of this project, a general unit outline of lesson order and topic is provided, although it is assumed that this would have been created with student input and that it is open to adjustments throughout the course of the unit as needed.
CHAPTER FOUR: THE UNIT

This PBL curriculum unit was created using a backwards design planning approach and it is intended to teach selected expectations from the grade 7 Ontario curriculum. It is an integrated unit, as most project-based-learning units are, and covers overall and specific expectations from the Mathematics: Number Sense and Numeration, Mathematics: Measurement, Science: Understanding Structures and Mechanisms, and the Language: Media Literacy strands. As well as covering curriculum content, the activities, lessons, and assessment tasks included in this unit are designed to foster the development of 21st century skills including effective communication, collaboration, and problem solving.

The curriculum unit was designed using a PBL approach and, as such, student voice and choice plays an integral role throughout the unit. This student-centred learning approach encourages students to take an active role in their learning and gives students input over how they will demonstrate their learning and how they will be assessed. Students and the teacher will co-create the success criteria and assessment tools of this unit, ensuring the assessment process is transparent to students.

One of the goals of this project was to facilitate educators’ understanding of how PBL can be implemented in a mathematics context. Educators are encouraged to use this unit as a guide for implementing PBL in their own classes. Teachers can follow this curriculum unit plan as it is written here, or they are welcome to adjust it as is needed to suit the needs of their students.
Let’s Build a House!

A Grade 7 Project-Based Learning Unit

Mathematics, Science & Language
Let’s Build a House!  Unit Overview
A Grade 7 Project-Based Learning Unit  Mathematics, Science & Language

Unit Summary

Let’s Build a House is a curriculum unit designed to teach expectations from Ontario’s grade 7 mathematics curriculum, while also integrating curriculum expectations from the science and language curriculums. Using the principles of Project-Based Learning, students will work in groups of 3-4 to plan, design, and build a model of a house.

Students will develop their understanding of mathematical operations using fractions, decimals, metric conversions, and area applications by developing scale drawings, working on cost analyses, and determining the square footage of their house design for flooring. Students will also develop their financial literacy as they conduct cost analysis and make budgeting decisions throughout the process of designing their house. Science expectations from the Understanding Structures and Mechanisms strand are also addressed in this unit, as students will explore different building materials and structural designs for their house plans. Finally, Language expectations from the Media Arts strand are integrated through the unit as students must prepare an advertising pamphlet to promote their home design.

In accordance with the principles of Project-Based Learning, students will also be developing several 21st century skills during this unit. Collaboration, problem solving, and effective communication skills are woven in nearly all aspects of this unit and will contribute to students’ development of these skills.

Key Features

Grade: Seven

Subject Strands:
- Mathematics
- Measurement
- Number Sense and Numeration
- Science
- Understanding Structures and Mechanisms
- Language
- Media Literacy

Duration: Approximately 32 periods
(40 minutes each)

Driving Question: How do we plan and design a new house?
21st Century Competencies:
- Problem Solving
- Collaboration
- Communication

Products:
- Blueprints of the entire house
- Scale model of the exterior of the house and building plans
- Cost calculations (including area calculations and unit rates)
- Advertising pamphlet

Public Audience: Final products will be shared at a mock showroom exhibit of all new house designs. Family and friends, as well as relevant audience members, like interior designers, will be present to provide feedback and to celebrate student success.

Curriculum Expectations Covered:

Mathematics: Number Sense and Numeration

Overall Expectation:
- demonstrate an understanding of addition and subtraction of fractions and integers, and apply a variety of computational strategies to solve problems involving whole numbers and decimal numbers.
- demonstrate an understanding of proportional relationships using percent, ratio, and rate.

Specific Expectations:
- solve multi-step problems arising from real-life contexts and involving whole numbers and decimals, using a variety of tools
- evaluate expressions that involve whole numbers and decimals, including expressions that contain brackets, using order of operations
- determine, through investigation, the relationships among fractions, decimals, percents, and ratios
- solve problems involving the calculation of unit rates

Mathematics: Measurement

Overall Expectation:
- report on research into real-life applications of area measurements

Specific Expectation:
- research and report on real-life applications of area measurements
- solve problems that require conversion between metric units of measure
- estimate and calculate the area of composite two-dimensional
shapes by decomposing into shapes with known area relationships

Science: Understanding Structures and Mechanisms
Overall Expectations:
1. analyse personal, social, economic, and environmental factors that need to be considered in designing and building structures and devices.
2. design and construct a variety of structures and investigate the relationship between the design and function of these structures and the forces that act on them.

Specific Expectations:
1.1 evaluate the importance for individuals, society, the economy, and the environment of factors that should be considered in designing and building structures and devices to meet specific needs
2.1 follow established safety procedures for using tools and handling materials
2.2 design, construct, and use physical models to investigate the effects of various forces on structures
2.4 use technological problem-solving skills (see page 16) to determine the most efficient way for a structure (e.g., a chair, a shelf, a bridge) to support a given load
2.6 use appropriate science and technology vocabulary in oral and written communication
2.7 use a variety of forms (e.g., oral, written, graphic, multimedia) to communicate with different audiences and for a variety of purposes

Language: Media Literacy
Overall Expectation:
1. demonstrate an understanding of a variety of media texts
3. create a variety of media texts for different purposes and audiences, using appropriate forms, conventions, and techniques

Specific Expectations:
1.1 explain how various media texts address their intended purpose and audience
3.3 identify conventions and techniques appropriate to the form chosen for a media text they plan to create, and explain how they will use the conventions and techniques to help communicate their message
3.4 produce a variety of media texts of some technical complexity
for specific purposes and audiences, using appropriate forms, conventions, and techniques

**Resources Needed:**
- Sample real estate pamphlets
- Sample blueprints of houses and lots
- Sample images of model homes in real estate offices
- Toothpicks
- Marshmallows
- Graph paper
- Blank paper
- Rulers
- Coloured construction paper
- Balsa wood
- Wooden skewers
- Cardboard strips
- Plastic straws
- Xacto knives
- Hot glue gun
- Paint
- Paint brushes
- Coloured pencils
- Markers
# Let’s Build a House! Lessons & Assessment Overview

**A Grade 7 Project-Based Learning Unit**

Mathematics, Science & Language

<table>
<thead>
<tr>
<th>Lesson #</th>
<th>Duration</th>
<th>Curriculum Expectations</th>
<th>Assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1</strong></td>
<td>1 period</td>
<td>None taught</td>
<td>KWL Chart: Assessment for learning (diagnostic)</td>
</tr>
<tr>
<td>Introduction to the Project</td>
<td></td>
<td>-</td>
<td>KWL Chart: Assessment as learning (self-assessment)</td>
</tr>
<tr>
<td><strong>2</strong></td>
<td>1 period</td>
<td><strong>Language: Media Literacy</strong></td>
<td>Create Pamphlet Checklist: will be used as an assessment of learning (summative)</td>
</tr>
<tr>
<td>Investigating Real Estate Ads</td>
<td></td>
<td>Overall Expectation:</td>
<td>Teacher observation and anecdotal notes: Assessment for learning (formative)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1. demonstrate an understanding of a variety of media texts</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>3. create a variety of media texts for different purposes and audiences, using appropriate forms, conventions, and techniques</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Specific Expectations:</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.1 explain how various media texts address their intended purpose and audience</td>
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<tr>
<td></td>
<td></td>
<td>3.3 identify conventions and techniques appropriate to the form chosen for a media text they plan to create, and explain how they will use the conventions and techniques to help communicate their message</td>
<td></td>
</tr>
<tr>
<td><strong>3</strong></td>
<td>1 period</td>
<td><strong>Science: Understanding Structures and Mechanisms</strong></td>
<td>Teacher observation and anecdotal notes: Assessment for learning (formative)</td>
</tr>
<tr>
<td>Investigating Design Choices</td>
<td></td>
<td>Overall Expectations:</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>1. analyse personal, social, economic, and environmental factors that need to be considered in designing and building structures and devices.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Specific Expectations:</td>
<td></td>
</tr>
</tbody>
</table>
| Work Period: Home Layout | 2 periods | **Science: Understanding Structures and Mechanisms**  
Overall Expectations:  
1. analyse personal, social, economic, and environmental factors that need to be considered in designing and building structures and devices.  
Specific Expectations:  
1.1 evaluate the importance for individuals, society, the economy, and the environment of actors that should be considered in designing and building structures and devices to meet specific needs | Teacher – Students Conference: Assessment for learning (formative)  
Exit Card – Assessment as learning (self-assessment)  
Exit Card – Assessment for learning (formative) |
|---|---|---|
| 5  
Scales and Scale Drawings | 1 period | **Mathematics: Number Sense and Numeration**  
Overall Expectations:  
-demonstrate an understanding of proportional relationships using percent, ratio, and rate.  
Specific Expectations:  
-determine, through investigation, the relationships among fractions, decimals, percents, and ratios  
**Mathematics: Measurement:**  
Overall Expectation:  
-report on research into real-life applications of area measurements  
Specific Expectation:  
-solve problems that require conversion between metric units of measure | Teacher observation and anecdotal notes: Assessment for learning (formative) |
| 6 | Scale Drawings | 2 periods | Mathematics: Number Sense and Numeration |
|   |               |          | Overall Expectations: |
|   |               |          | - demonstrate an understanding of proportional relationships using percent, ratio, and rate. |
|   |               |          | Specific Expectations: |
|   |               |          | - determine, through investigation, the relationships among fractions, decimals, percents, and ratios |
|   |               |          | Mathematics: Measurement: |
|   |               |          | Overall Expectation: |
|   |               |          | - report on research into real-life applications of area measurements |
|   |               |          | Specific Expectation: |
|   |               |          | - solve problems that require conversion between metric units of measure |
|   | Scale Drawing Task – Assessment for learning (formative) | 3, 2, 1 – Assessment as learning (self-assessment) |

| 7 | Work Period: Scale Drawings of House | 3 periods | Mathematics: Number Sense and Numeration |
|   |                                        |          | Overall Expectations: |
|   |                                        |          | - demonstrate an understanding of proportional relationships using percent, ratio, and rate. |
|   |                                        |          | Specific Expectations: |
|   |                                        |          | - determine, through investigation, the relationships among fractions, decimals, percents, and ratios |
|   |                                        |          | Mathematics: Measurement: |
|   |                                        |          | Overall Expectation: |
|   |                                        |          | - report on research into real-life applications of area measurements |
|   |                                        |          | Specific Expectation: |
|   |                                        |          | - solve problems that require conversion between metric units of measure |
|   | Create Blueprint Rubric – will be used as an assessment of learning (summative) |
|   | Teacher – Students Conference: Assessment for learning (formative) |

| 8 | Introduction to Structures | 2 periods | Science: Understanding Structures and Mechanisms |
|   |                            |          | Overall Expectations: |
|   |                            |          | 2. design and construct a variety of |
|   |                            |          | Sticky Note Activity: Assessment for learning |
| 9 Building Materials | 1 period | **Science: Understanding Structures and Mechanisms**  
Overall Expectations:  
2. design and construct a variety of structures and investigate the relationship between the design and function of these structures and the forces that act on them.  
Specific Expectations:  
2.1 follow established safety procedures for using tools and handling materials  
2.2 design, construct, and use physical models to investigate the effects of various forces on structures  
2.4 use technological problem-solving skills (see page 16) to determine the most efficient way for a structure (e.g., a chair, a shelf, a bridge) to support a given load  
2.6 use appropriate science and technology vocabulary in oral and written communication  
2.7 use a variety of forms (e.g., oral, written, graphic, multimedia) to communicate with different audiences and for a variety of purposes | (diagnostic)  
Teacher observation and anecdotal notes:  
Assessment for learning (formative)  
Exit Card:  
Assessment as learning (self-assessment)  
Exit Card:  
Assessment for learning (formative) |
| Work Period: Building Plans | 2 periods | **Science: Understanding Structures and Mechanisms**
Overall Expectations: 
2. design and construct a variety of structures and investigate the relationship between the design and function of these structures and the forces that act on them.
Specific Expectations: 
2.1 follow established safety procedures for using tools and handling materials 
2.2 design, construct, and use physical models to investigate the effects of various forces on structures 
2.4 use technological problem-solving skills (see page 16) to determine the most efficient way for a structure (e.g., a chair, a shelf, a bridge) to support a given load 
2.6 use appropriate science and technology vocabulary in oral and written communication 
2.7 use a variety of forms (e.g., oral, written, graphic, multimedia) to communicate with different audiences and for a variety of purposes

| Create Model Home Rubric: will be used as an assessment of learning (summative) 
Teacher-student conference: Assessment for learning (formative) 

**Mathematics: Number Sense and Numeration**
Overall Expectations:  
- demonstrate an understanding of proportional relationships using percent, ratio, and rate.

Specific Expectations:  
- determine, through investigation, the relationships among fractions, decimals, percents, and ratios

Mathematics: Measurement:  
Overall Expectation:  
- report on research into real-life applications of area measurements

Specific Expectation:  
- solve problems that require conversion between metric units of measure

11 Calculating Costs  
2 periods  
Mathematics: Measurement  
Overall Expectation:  
- report on research into real-life applications of area measurements

Specific Expectation:  
- research and report on real-life applications of area measurements

Mathematics: Number Sense and Numeration  
Overall Expectation:  
- demonstrate an understanding of addition and subtraction of fractions and integers, and apply a variety of computational strategies to solve problems involving whole numbers and decimal numbers.

- demonstrate an understanding of proportional relationships using percent, ratio, and rate.

Specific Expectations:  
- solve multi-step problems arising from real-life contexts and involving whole numbers and decimals, using a variety of tools

- evaluate expressions that involve

Teacher observation and anecdotal notes:  
Assessment for learning (formative)

Traffic Light:  
Assessment as learning (self-assessment)
whole numbers and decimals, including expressions that contain brackets, using order of operations
-solve problems involving the calculation of unit rates

| 12 Area of Composite Shapes | 1 period | **Mathematics: Measurement**
Overall Expectation:
- report on research into real-life applications of area measurements
Specific Expectation:
- research and report on real-life applications of area measurements
  - solve problems involving the calculation of unit rates

**Mathematics: Number Sense and Numeration**
Overall Expectation:
- demonstrate an understanding of addition and subtraction of fractions and integers, and apply a variety of computational strategies to solve problems involving whole numbers and decimal numbers.
  - demonstrate an understanding of proportional relationships using percent, ratio, and rate.
Specific Expectations:
- solve multi-step problems arising from real-life contexts and involving whole numbers and decimals, using a variety of tools
  - evaluate expressions that involve whole numbers and decimals, including expressions that contain brackets, using order of operations
  - solve problems involving the calculation of unit rates

| 13 Work Period: Calculating Costs | 3 periods | **Mathematics: Measurement**
Overall Expectation:
- report on research into real-life applications of area measurements

**Create Cost Calculations Rubric:** will be used as an
| 14 Peer Feedback and Adjustments | 2 periods | **Mathematics: Number Sense and Numeration**  
Overall Expectation:  
- demonstrate an understanding of addition and subtraction of fractions and integers, and apply a variety of computational strategies to solve problems involving whole numbers and decimal numbers.  
- demonstrate an understanding of proportional relationships using percent, ratio, and rate.  
Specific Expectations:  
- solve multi-step problems arising from real-life contexts and involving whole numbers and decimals, using a variety of tools  
- evaluate expressions that involve whole numbers and decimals, including expressions that contain brackets, using order of operations  
- solve problems involving the calculation of unit rates | Peer Feedback: Assessment as learning (peer-assessment)  
Teacher-student conference: Assessment for learning (formative)

### Specific Expectation:
- research and report on real-life applications of area measurements  
- solve problems involving the calculation of unit rates  

**Mathematics: Number Sense and Numeration**
Overall Expectation:
- demonstrate an understanding of addition and subtraction of fractions and integers, and apply a variety of computational strategies to solve problems involving whole numbers and decimal numbers.
- demonstrate an understanding of proportional relationships using percent, ratio, and rate.
Specific Expectations:
- solve multi-step problems arising from real-life contexts and involving whole numbers and decimals, using a variety of tools
- evaluate expressions that involve whole numbers and decimals, including expressions that contain brackets, using order of operations
- solve problems involving the calculation of unit rates

### Teacher-student conference:
Assessment for learning (formative)
from real-life contexts and involving whole numbers and decimals, using a variety of tools
- evaluate expressions that involve numbers and decimals, including expressions that contain brackets, using order of operations
- determine, through investigation, the relationships among fractions, decimals, percents, and ratios
- solve problems involving the calculation of unit rates

**Mathematics: Measurement**
Overall Expectation:
- report on research into real-life applications of area measurements
Specific Expectation:
- research and report on real-life applications of area measurements
- solve problems that require conversion between metric units of measure
- estimate and calculate the area of composite two-dimensional shapes by decomposing into shapes with known area relationships

**Science: Understanding Structures and Mechanisms**
Overall Expectations:
2. design and construct a variety of structures and investigate the relationship between the design and function of these structures and the forces that act on them.
Specific Expectations:
2.2 design, construct, and use physical models to investigate the effects of various forces on structures
2.4 use technological problem-solving skills (see page 16) to determine the most efficient way for
### 15 Work Period: Building Models

**Science: Understanding Structures and Mechanisms**

**Overall Expectations:**
- 2. design and construct a variety of structures and investigate the relationship between the design and function of these structures and the forces that act on them.

**Specific Expectations:**
- 2.1 follow established safety procedures for using tools and handling materials
- 2.2 design, construct, and use physical models to investigate the effects of various forces on structures
- 2.4 use technological problem-solving skills (see page 16) to determine the most efficient way for a structure (e.g., a chair, a shelf, a bridge) to support a given load
- 2.6 use appropriate science and technology vocabulary in oral and written communication
- 2.7 use a variety of forms (e.g., oral, written, graphic, multimedia) to communicate with different audiences and for a variety of purposes

**Teacher observation and anecdotal notes on safety using a rubric:**
**Assessment of learning (summative)**

### 16 Work Period: Advertising

**Language: Media Literacy**

**Overall Expectation:**
- 1. demonstrate an understanding of
### Pamphlet

<table>
<thead>
<tr>
<th>Pamphlet</th>
<th>a variety of media texts 3. create a variety of media texts for different purposes and audiences, using appropriate forms, conventions, and techniques Specific Expectations: 1.1 explain how various media texts address their intended purpose and audience 3.3 identify conventions and techniques appropriate to the form chosen for a media text they plan to create, and explain how they will use the conventions and techniques to help communicate their message 3.4 produce a variety of media texts of some technical complexity for specific purposes and audiences, using appropriate forms, conventions, and techniques</th>
<th>notes: Assessment for learning (formative) Pamphlet Checklist – Assessment as learning (self-assessment)</th>
</tr>
</thead>
<tbody>
<tr>
<td>17 Final Showroom</td>
<td>2 periods</td>
<td>Rubrics: Assessment of learning (summative) 2 Stars and 1 Wish: Assessment as learning (self-assessment)</td>
</tr>
</tbody>
</table>

| 17 Final Showroom | 2 periods | All curriculum expectations covered in this unit will be used and evaluated during this lesson. |

Final Showroom | 2 periods | All curriculum expectations covered in this unit will be used and evaluated during this lesson. | Rubrics: Assessment of learning (summative) 2 Stars and 1 Wish: Assessment as learning (self-assessment) |
Let’s Build a House!  
Lesson 1  
Introduction to the Project

Summary:
Students will be given the *Project Outline* sheet and it will be discussed and explained as a class. Students will explore model homes, real estate brochures, and real estate websites to brainstorm ideas for their own projects and to build excitement for the upcoming unit. Students will individually complete the first two columns of a KWL chart about what they already know about the process of home building, and what they want to learn (information, required skills, etc.). Students will also decide on their groups for the unit (3-4 students per group).

Curriculum Expectations:
- None formally taught

Resources/Materials Needed:
- Class set of *Project Outline* sheets  
- Class set of *KWL* sheets  
- Model home structures  
- Brochures and advertising posters from real estate offices

Instructional Plan:

<table>
<thead>
<tr>
<th>Time</th>
<th>Outline</th>
<th>Assessment Opportunities</th>
</tr>
</thead>
</table>
| 10 min| - Before class, the teacher will have brought in model homes, brochures, and posters from real estate companies and set them around the room.  

- Students will each be given a copy of the *Project Outline* sheet and the project will be discussed as a class. Students have the opportunity to ask questions about the project and the products they will be expected to submit. Student input is valued, so suggestions from students concerning products or the structure of the project should be discussed as a class and any changes must be agreed upon as a class. | |
<table>
<thead>
<tr>
<th>Time</th>
<th>Activity</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>15 min</td>
<td>Students will each be given a KWL chart. Review what needs to be written in each column (what I already KNOW, what I WANT to know, what I LEARNED). Students are to fill out the first two sections of this chart and consider what they already know that will help them with this project and what they want to know about this project to make them successful. Remind students that the final column of this chart will be completed at the conclusion of the project. To assist students in understanding the different steps of this project and to build excitement for the project, students will explore the model homes, brochures, and ads around the room while filling out this chart.</td>
<td>KWL charts will be collected by the teacher and reviewed as a means of diagnostic assessment. This kind of assessment for learning will give the teacher a baseline understanding of what students already know.</td>
</tr>
<tr>
<td>10 min</td>
<td>As a class, have students share some of the skills and knowledge they already have that will be useful in completing this project and what they want to learn by the end of it. Students may add to their own charts as new ideas come up through this discussion.</td>
<td>Self-assessment of current knowledge and needed knowledge is a form of assessment as learning for students.</td>
</tr>
<tr>
<td>5 min</td>
<td>Now that they have a better understanding of the project and what is expected to get done over the course of this unit, students will form groups of 3-4. Student choice is valued, so students should be given freedom to choose their own groups.</td>
<td></td>
</tr>
</tbody>
</table>

**Differentiating Instruction:**

- Students can be given an electronic version of the KWL chart so they can type their responses.
- Assistive technologies (i.e., speech to text programs) can be used to complete the KWL chart if needed.
Let’s Build a House! – Project Outline

Objective
You and your group members have been commissioned to design and build a new house for a local real estate company. To complete this project, we will be learning about the various planning and design processes involved in creating a new home.

Major Project Components
Your group will be responsible for creating and submitting:

- **Blueprints**
  - Full blueprints for the entire floor plan of your house.
  - Include blueprint symbols for features and appliances (stairs, sinks, doors, etc.).
  - Blueprints will be made according to an appropriate scale of your choosing.

- **Cost Analysis**
  - Calculate the cost of ALL flooring for your home.
  - Cost will depend on the type of flooring you choose for your home (hardwood, tile, carpet, or laminate). Prices for different flooring types will be provided to you in a later lesson.

- **Model Home and Design Plans**
  - Design plans will clearly show how you plan to build your model home and will include all measurements.
  - Model home and plans will be made according to an appropriate scale of your choosing.
  - Written justification for the design choices for your model that demonstrates your understanding of structures and forces.

- **Advertising Pamphlet**
  - Includes all necessary information about the house such as the number of bedrooms, square footage (in m²), local amenities, etc.
  - Clearly addresses your target audience (homebuyers).

Notes
- Assessment tools will be created with your input and will be provided throughout the unit.
- The more complicated you make your floor plans, the more complicated your project will get throughout the unit. Choose the size of your home wisely!
# Let’s Build a House! – KWL Chart

<table>
<thead>
<tr>
<th>What I ALREADY know</th>
<th>What I WANT to know</th>
<th>What I LEARNED</th>
</tr>
</thead>
</table>
Let’s Build a House!  
Lesson 2  
Investigating Real Estate Ads

Summary:
Students will look over real estate pamphlets and websites to gain a better understanding of how new homes are advertised effectively. Students will work with their groups to analyze the pamphlets and websites to identify features that promote new homes and that make the pamphlets appealing to potential homebuyers. To consolidate, groups will share ideas and co-construct a checklist of features that must be included in an advertising pamphlet. This checklist will be used as an assessment tool when groups create their own advertising pamphlets near the end of the unit.

Curriculum Expectations:

Language: Media Literacy

Overall Expectation:
1. demonstrate an understanding of a variety of media texts
3. create a variety of media texts for different purposes and audiences, using appropriate forms, conventions, and techniques

Specific Expectations:
1.1 explain how various media texts address their intended purpose and audience
3.3 identify conventions and techniques appropriate to the form chosen for a media text they plan to create, and explain how they will use the conventions and techniques to help communicate their message

Resources/Materials Needed:
- Real estate pamphlets
- Links to real estate websites
- Paper (1 per group)
- Chart paper (1 sheet)

Instructional Plan:

<table>
<thead>
<tr>
<th>Time</th>
<th>Outline</th>
<th>Assessment Opportunities</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>- Before class, the teacher will choose two online real estate postings to show to the students. One listing should be very simple and have limited information, while the other posting should provide several pictures and a good description of the home.</td>
<td></td>
</tr>
</tbody>
</table>
5 min - The teacher will show both webpages to the class and ask which house they would want to buy, based upon the information provided. Have students share their reasoning with the class. Point out that homes that are better advertised are often more appealing to potential buyers, which is why advertising pamphlets and websites are important.

25 min - Working with their project groups, students will analyze several advertising pamphlets to identify the features that make an effective advertising tool. Students should consider what kinds of information potential homebuyers would want to know. Each group will record this list on a sheet of paper.

10 min - After all groups have finished their own lists, they will share their points with the class. The class will then co-construct a checklist of important features that need to be included in their own advertising pamphlets. The teacher will record the agreed upon features on a piece of chart paper. This list will be used as an assessment tool at the end of the unit when students submit their own advertising pamphlets.

Differentiating Instruction:
- Students may choose to type their lists if needed.
- Assistive technology (i.e., speech to text programs) can be used if needed.
- Teacher can provide prompting ideas for students if needed.

- Teacher observation is used as an assessment tool to assess students’ understanding of advertising techniques. Observations should be recorded as anecdotal notes.

- This co-constructed checklist will be used as an assessment tool for groups to ensure they have included the necessary features in their own pamphlets at the end of the unit.
**Sample Checklist for the Advertising Pamphlet**

When creating your advertising pamphlet for your new house, be sure to include the following:

- Pictures of the house (of the model you have created)
- Cost of flooring upgrades
- Square-footage (given in m$^2$)
- List of rooms (number of bedrooms, bathrooms, etc.)
- List of key features (fireplace, hardwood floors, etc.)
- Blueprints of the entire house
- Nearby amenities (is it near a school, mall, community centre, etc.?)
- Contact information of builder/realtor

*Also make sure your pamphlet appeals to target audience (homebuyers)*
Lesson 3
Investigating Design Choices

Summary:
Students will be investigating the design choices involved in building a house. They will complete the *Home Investigation* sheet by listing the different rooms of a home and the design considerations that will be required for planning each room. Students must include the appliances needed in each room and the kinds of flooring that may be used.

Curriculum Expectations:

*Science: Understanding Structures and Mechanisms*

Overall Expectations:
1. analyse personal, social, economic, and environmental factors that need to be considered in designing and building structures and devices.

Specific Expectations:
1.1 evaluate the importance for individuals, society, the economy, and the environment of factors that should be considered in designing and building structures and devices to meet specific needs.

Resources/Materials Needed:
- Class set of *Home Investigation* sheets

Instructional Plan:

<table>
<thead>
<tr>
<th>Time</th>
<th>Outline</th>
<th>Assessment Opportunities</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 min</td>
<td>-Begin the class by having students think quietly (without saying it out loud) about how many rooms they think the house they are building will have. After giving students a minute or two to consider this question individually, ask students to raise their hand if they plan on having at least two rooms... at least 3 rooms... 4... Continue until all students have lowered their hands. Point out how everyone has different ideas about how many rooms the house will have and discuss possible factors that played into their decision. For instance, a large house may have more bedrooms than a smaller one. Some students</td>
<td></td>
</tr>
</tbody>
</table>
may plan for one large family room, while others will have separate living room, dining room, and family room.

| 25 min | -Explain to students that before we can start designing our houses, we need to know what rooms and features we need to include in the plans. Hand out the *Home Investigation* sheets and discuss the example provided. Students will work individually to complete the first two columns of this worksheet. The third column is to be completed as homework and will be used as a size reference in future lessons. Students can fill out room measurements based on their own house or they can find sample room sizes online. |
| 10 min | -When students have finished the first two columns, they can meet with their project groups to compare sheets and add any ideas they forgot. |

**Teacher observation is an assessment for learning tool used to determine students’ understanding of the factors that go into making design choices.**

**Differentiating Instruction:**
- Students may choose to type their lists if needed.
- Assistive technology (i.e., speech to text programs) can be used if needed.
Let’s Build a House! – Home Investigation

<table>
<thead>
<tr>
<th>Room</th>
<th>Design Considerations</th>
<th>Measurements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Example:</td>
<td>-Needs: toilet, sink</td>
<td>2m x 3m</td>
</tr>
<tr>
<td>Bathroom</td>
<td>-Optional: shower, bathtub</td>
<td></td>
</tr>
<tr>
<td></td>
<td>-Floor is usually tiled or laminate (no carpet)</td>
<td></td>
</tr>
</tbody>
</table>


Let’s Build a House!  

Lesson 4  

Duration: 2 periods  
Work Period: Begin Home Layout

Summary:
Students will view some basic floor plans and discuss the features included. Groups will then be given time to start planning the layout of the home they are designing. Students will reference the Home Investigation sheet from lesson 3 as they work on their layout to ensure they are including important features (e.g., closets, appliances, etc.) in their plans. An Exit Card will be completed to check-in on students’ understanding of topics covered thus far in the unit.

Curriculum Expectations:

Science: Understanding Structures and Mechanisms

Overall Expectations:
1. analyse personal, social, economic, and environmental factors that need to be considered in designing and building structures and devices.

Specific Expectations:
1.1 evaluate the importance for individuals, society, the economy, and the environment of factors that should be considered in designing and building structures and devices to meet specific needs.

Resources/Materials Needed:
- Simple home blueprints
- Blank paper
- Rulers
- Class set of Blueprint Symbols sheet
- Class set of Exit Cards

Instructional Plan:

<table>
<thead>
<tr>
<th>Time</th>
<th>Outline</th>
<th>Assessment Opportunities</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 min</td>
<td>- Begin the lesson by showing the class a few simple blueprints of homes (no measurements included at this point). As a class, discuss the different symbols used in the blueprints and what they represent (how to mark walls, doors, stairs, sinks, etc.). Discuss why it is important for architects to use agreed upon symbols when creating blueprints.</td>
<td></td>
</tr>
</tbody>
</table>
Each group will use blank paper, pencils, and rulers to begin working on the layout of their home. Remind students to refer to their *Home Investigation* sheet from Lesson 3 to ensure they are including all necessary rooms and features in their plans. At this time, no measurements are required on their blueprints as the focus is on creating the layout of the home and practicing using blueprint symbols. The teacher will circulate between groups, conferencing with each group to assist where needed and to record anecdotal notes.

As a class, discuss next steps. What do students need to add to their blueprints? If not brought up by students, prompt them to consider measurements and scale. Discuss the importance of including accurate measurements. Tell students this topic will be covered in the next lesson. Give each student an *Exit Card*, have them answer the questions, and hand it in before the end of class.

**Differentiating Instruction:**
- Students that may have difficulty drawing due to fine motor control issues can use software programs to create digital blueprints instead of hand drawing them. Alternatively, since the blueprints are completed as a group, another group member may choose to draw them.
- The teacher will circulate and assist groups with questions as needed.
- Groups decide how complicated they want their blueprints to be, and can choose a difficulty that matches their ability level. For instance, a two-story house will be more work than a single-story house, and oddly shaped rooms will provide more challenging in future stages of the project.

Teacher-student conferences will occur throughout the work period. These formative observations will be recorded by the teacher as anecdotal notes to track groups’ progress and questions.

The *Exit Card* is a form of assessment as learning and gives students a chance to evaluate their understanding thus far and ask any outstanding questions.
Exit Card - Blueprints

Rate your understanding of creating blueprints so far:

1. Very confused
2. Okay
3. Very Good

What questions do you still have? What topics would you like the class to review?
Let’s Build a House!  
**Lesson 5**  
Scales and Scale Drawings

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**Summary:**
Students will be introduced to scale drawings, their importance, and how they are calculated. Students will use scale factors (fractions) to calculate scale drawings according to the scale (ratio) assigned.

**Curriculum Expectations:**

*Mathematics: Number Sense and Numeration*

**Overall Expectations:**
- demonstrate an understanding of proportional relationships using percent, ratio, and rate.

**Specific Expectations:**
- determine, through investigation, the relationships among fractions, decimals, percents, and ratios

*Mathematics: Measurement:*

**Overall Expectation:**
- report on research into real-life applications of area measurements

**Specific Expectation:**
- solve problems that require conversion between metric units of measure

**Resources/Materials Needed:**
- Sample blueprint with no measurements
- Metre sticks
- Blank paper
- Calculators
  - *Scale Drawing Anchor Chart*

**Instructional Plan:**

<table>
<thead>
<tr>
<th>Time</th>
<th>Outline</th>
<th>Assessment Opportunities</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 min</td>
<td>-Show students a blueprint of room that does not have any measurements or scale factors. Ask students how long the room is. Students should quickly realize that without any measurements or scale factors given, we cannot tell. Explain that this is the reason we need to include scale factors on our blueprints.</td>
<td></td>
</tr>
</tbody>
</table>
59

15 min - Show students the *Scale Drawings Anchor Chart* and discuss the definitions of scales, scale factors, and ratios. Go over the example questions on the chart with the class. Discuss the steps needed to solve the questions. Make sure this chart is posted in the room so students can refer back to it throughout the unit.

10 min - With the class, measure one of the desktops and record the dimensions (e.g., 70cm x 50cm). Then, working in their project groups, assign each group a scale factor (2, ½, ¼, etc). Each group will then calculate dimensions of the scaled desk according to the scale they were assigned. If possible, students are to draw the desk according to scale. Note that some students will be assigned scale factors larger than 1, and therefore their drawings would have to be larger than the actual desk – these may not be possible for students to draw depending on the size of paper available.

10 min - Each group will share their work with the class and explain the steps they took. Discuss how although all of the scaled desks are different sizes, they are all proportional to the original desk.

- Teacher observation and anecdotal notes throughout this lesson are assessments for learning of students’ abilities and knowledge about scale factors, metric units, and the relationship between scales (ratios) and scale factors (fractions).

**Differentiating Instruction:**
- The teacher will circulate and assist groups as needed.
- Groups will be assigned a scale factor according to their abilities. Benchmark fractions can be given to lower ability groups, while more difficult fractions can be given to others.
Let’s Build a House! - Scale Drawings Anchor Chart

**Scale**: The ratio of any two corresponding lengths in two similar figures. The lengths do not need to have the same units.

**Examples**: $1cm = 2cm$, $1cm = 5m$

**Scale Factor**: The number we multiply our original length by to get the scaled length. The scale factor tells us how much bigger or smaller the scaled drawing is compared to the original.

**Examples**: $\frac{1}{2}$, 2, 5, $1/100$

**Question**: If a table is $100cm$ long in real life and $50cm$ in the scale drawing, what scale is used? What is the scale factor?

Scale: new length = original length

$50 \text{ cm} = 100 \text{ cm}$  ---> put this into lowest terms

$1\text{ cm} = 2 \text{ cm}$

Scale factor = new length/original length

$= \frac{50\text{ cm}}{100 \text{ cm}}$

$= \frac{1}{2}$

This means our new drawing is $\frac{1}{2}$ the length of the original. We can now multiply any length by our scale factor to find out how long it will be in the scale drawing. **Notice that when a scale factor is smaller than 1, our new drawing is smaller than the original**

**Question**: If a room measures $4m \times 6m$, and the scale is $1cm = 2m$, what should the dimensions of the room be in our scale drawing?

**Question**: If we have a scale drawing of a room that measures $5.5cm \times 4cm$ and we are given the scale $1cm = 3m$, what are the actual dimensions of the room?
Let’s Build a House!

Duration: 2 periods

Lesson 6
Scale Drawings

Summary:
Students will be given an individual, formative assessment task in which they are to create a scale drawing of the classroom. Students must decide upon a reasonable scale for their drawing, show all calculations, and submit their drawing. The teacher will provide formative descriptive feedback for students prior to moving on to Lesson 7.

Curriculum Expectations:

Mathematics: Number Sense and Numeration
Overall Expectations:
- demonstrate an understanding of proportional relationships using percent, ratio, and rate.
Specific Expectations:
- determine, through investigation, the relationships among fractions, decimals, percents, and ratios

Mathematics: Measurement:
Overall Expectation:
- report on research into real-life applications of area measurements
Specific Expectation:
- solve problems that require conversion between metric units of measure

Resources/Materials Needed:
- Metre sticks
- Grid paper
- Lined paper
- Calculators
- Class set of 3, 2, 1 self-assessment sheets

Instructional Plan:

<table>
<thead>
<tr>
<th>Time</th>
<th>Outline</th>
<th>Assessment Opportunities</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 min</td>
<td>- The teacher will ask students to brainstorm the necessary steps when creating a scale drawing blueprint. Students will have two minutes to discuss with their groups, and then</td>
<td></td>
</tr>
</tbody>
</table>
will share their ideas with the class. If not brought up by students, prompt them to choose an appropriate scale, find original measurements, scale the measurements, draw the room according to scale, and finally, add necessary blueprint symbols.

<table>
<thead>
<tr>
<th>Time</th>
<th>Activity</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 min</td>
<td>Introduce students to the task for this lesson: drawing a scaled blueprint of the classroom. Remind students to include all of the steps that have just been discussed. Students must hand in their blueprint drawing and an accompanying sheet with the calculations.</td>
<td>These assignments will be collected and will be used as an assessment for learning. The teacher will provide written descriptive feedback on these assignments to students prior to lesson 7.</td>
</tr>
<tr>
<td>60 min</td>
<td>Students will have this time to work on the task. Remind students that this is an individual assignment. The teacher will circulate through the room and assist students as needed.</td>
<td></td>
</tr>
<tr>
<td>10 min</td>
<td>Ask students to stop what they are doing, even if they have not completely finished their blueprints. Ask students to complete the 3, 2, 1 self-assessment sheet and hand it in. This requires students to discuss 3 things they did well on this task, 2 things they can improve on, and 1 outstanding question they have.</td>
<td>The self-reflections are an assessment as learning tools. Students can reflect on what they did well and what they need to improve on.</td>
</tr>
</tbody>
</table>

**Differentiating Instruction:**
- The teacher will circulate the classroom and assist students as needed.
- Students who may have difficulty drawing due to fine motor control issues can use software programs to create digital blueprint instead of hand drawing them.
- Students who are having trouble determining a reasonable scale can consult with the teacher and one can be decided upon together.
3, 2, 1 Self-Assessment

3 things I think I did well on this task were:
- 
- 
- 

2 things I think I can improve on are:
- 
- 

1 outstanding question I have is:
- 

Name: __________________
Let’s Build a House!  
Lesson 7  
Duration: 3 periods  
Work Period – Scale Drawing of House

Summary:  
Students will have a chance to review the feedback they received on their scale drawings of the classroom from Lesson 6. As a class, common misunderstandings will be reviewed. Students will then be given time to work with their project groups on scaling their home layout from Lesson 4. The focus here is to choose a reasonable scale for their drawing and then to draw their blueprints according to the chosen scale.

Curriculum Expectations:  

Mathematics: Number Sense and Numeration  
Overall Expectations:  
- demonstrate an understanding of proportional relationships using percent, ratio, and rate.  
Specific Expectations:  
- determine, through investigation, the relationships among fractions, decimals, percents, and ratios

Mathematics: Measurement:  
Overall Expectation:  
- report on research into real-life applications of area measurements  
Specific Expectation:  
- solve problems that require conversion between metric units of measure

Resources/Materials Needed:  
- Grid paper  
- Lined paper  
- Rulers  
- Calculators  
- Class set of Blueprints Rubric

Instructional Plan:  

<table>
<thead>
<tr>
<th>Time</th>
<th>Outline</th>
<th>Assessment Opportunities</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 min</td>
<td>- The teacher will give students back their scale drawing task from Lesson 6, along with written descriptive feedback. As students have a chance to look over the feedback, the teacher</td>
<td></td>
</tr>
</tbody>
</table>
will review any outstanding questions mentioned on the 3, 2, 1 self-assessment, and also review any common errors from the assignment.

5 min  - Hand out the Blueprints Rubric. Explain to students that this is the rubric that will be used to assess their final blueprints, which they will be starting on today. Discuss each of the criteria on the rubric and answer any questions students have about it.

- This rubric will be used as an assessment of learning at the end of the unit.

100 min - Students will be given time to work in their groups and start on their final blueprints. They will use the home layout they created in Lesson 4 as a guide, and redraw this layout according to the scale of their choice. Students must include the appropriate blueprint symbols (e.g., doors, stairs, sink, etc.) in their blueprints. Note: This work period can be split up over more than one day if needed.

- The teacher will conference with each group and record anecdotal notes about student progress and group participation. This is an assessment for learning tool.

5 min  - Bring students back together as a class and ask them about necessary next steps for the project. Now that they have blueprints done, they will be moving on to how they will be building their model. Before students begin building, they will be learning about structures and how to build them.

Differentiating Instruction:
- The teacher will circulate the classroom and assist students as needed.
- Students who may have difficulty drawing due to fine motor control issues can use software programs to create digital blueprint instead of hand drawing them. Alternatively, since only one set of blueprints is needed for each group, another student can draw it.
- Groups that are having trouble determining a reasonable scale can consult with the teacher and one can be decided upon together.
# Let’s Build a House! – Blueprints Rubric

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Level 4</th>
<th>Level 3</th>
<th>Level 2</th>
<th>Level 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Appropriateness of Scale</td>
<td>The chosen scale demonstrates a high level of proportional understanding and is appropriate for this purpose.</td>
<td>The chosen scale demonstrates a sufficient level of proportional understanding and is appropriate for this purpose.</td>
<td>The chosen scale demonstrates some level of proportional understanding and is somewhat appropriate for this purpose.</td>
<td>The chosen scale demonstrates a limited level of proportional understanding and is not appropriate for this purpose.</td>
</tr>
<tr>
<td>Scale Drawing</td>
<td>All aspects are drawn correctly according to the chosen scale.</td>
<td>Most aspects are drawn correctly according to the chosen scale.</td>
<td>Some aspects are drawn correctly according to the chosen scale.</td>
<td>Few aspects are drawn correctly according to the chosen scale.</td>
</tr>
<tr>
<td>Inclusiveness of Layout</td>
<td>The layout of the home demonstrates a high level of understanding of various design factors.</td>
<td>The layout of the home demonstrates considerable understanding of various design factors.</td>
<td>The layout of the home demonstrates some understanding of various design factors.</td>
<td>The layout of the home demonstrates limited understanding of various design factors.</td>
</tr>
<tr>
<td>Use of Blueprint Symbols</td>
<td>Correct blueprint symbols are always used.</td>
<td>Correct blueprint symbols are mostly used.</td>
<td>Correct blueprint symbols are sometimes used.</td>
<td>Correct blueprint symbols are rarely used.</td>
</tr>
</tbody>
</table>
Let’s Build a House!  
Lesson 8  
Introduction to Structures  
---------------------------------------------------------------------------------------------------------------------
Duration: 2 periods  

Summary:  
Students will be introduced to structures and the forces that act on them. Students will work in their project groups to complete a design/build challenge to create a structure with maximum height. Structures will be compared and students will discuss design factors that made the structures successful.

Curriculum Expectations:  
Science: Understanding Structures and Mechanisms  
Overall Expectations:  
2. design and construct a variety of structures and investigate the relationship between the design and function of these structures and the forces that act on them.

Specific Expectations:  
2.1 follow established safety procedures for using tools and handling materials  
2.2 design, construct, and use physical models to investigate the effects of various forces on structures  
2.4 use technological problem-solving skills (see page 16) to determine the most efficient way for a structure (e.g., a chair, a shelf, a bridge) to support a given load  
2.6 use appropriate science and technology vocabulary in oral and written communication  
2.7 use a variety of forms (e.g., oral, written, graphic, multimedia) to communicate with different audiences and for a variety of purposes

Resources/Materials Needed:  
- 2 pieces of chart paper  
- Sticky notes (several for each student)  
- Toothpicks  
- Marshmallows

Instructional Plan:  
<table>
<thead>
<tr>
<th>Time</th>
<th>Outline</th>
<th>Assessment Opportunities</th>
</tr>
</thead>
<tbody>
<tr>
<td>15 min</td>
<td>- The teacher will give each student a few sticky notes. There will be two pieces of chart paper at the front of the room entitled “Structures” and “Forces”. Each student is to</td>
<td>- This activity acts as a diagnostic assessment (assessment for learning) that will determine what</td>
</tr>
</tbody>
</table>
write what he or she already knows about these terms on a sticky note and stick it onto the appropriate chart paper. Students may write key vocabulary terms, examples of structures/forces, etc. Once all sticky notes have been placed, discuss the points with the class. Introduce key vocabulary (beams, truss, etc.) and forces (compression, tension, etc.) if they are not provided on sticky notes.

15 min  -The teacher will then tell students about the build challenge they will be completing during this lesson. Students will work with their project groups to design and build the tallest free-standing structure possible using the materials given. Each group will be given 100 toothpicks and 100 tiny marshmallows. Before students begin, brainstorm important safety procedures with the class. Stress that each build challenge will have different safety requirements depending on the task and materials being used. If not brought up by students, prompt them to consider if any kind of safety equipment is necessary. Ensure the safety procedures are displayed at all times for students to refer back to.

35 min  -Students will be given this time to work together in their groups to design and build their structure. The teacher will circulate and assist as needed.

15 min  -The teacher will give students a few minutes to walk around and look at the structures made by the other groups. As a class, discuss what factors seem to determine how tall a structure can be. For example, did the structure have a solid base, did they include triangles to add support, etc. Ask students to complete the exit card about what they would do differently if they could do this challenge again. Encourage them to use key vocabulary prior knowledge students have on this topic. Depending on students’ prior knowledge, a more in depth review of key vocabulary may be necessary.

-Teacher observation and anecdotal notes will be used to record students’ use of key vocabulary and whether they are following the safety procedures.

-Exit Card is an assessment as learning, as students reflect on their own learning process. It can also be used as a formative assessment of students’ understanding of key vocabulary and design.
discussed at the beginning of the lesson.

Differentiating Instruction:
- Teacher will circulate the room and assist students as is needed.
- Students with fine motor control issues can provide ideas to the group while their group members build it.
Exit Card – Build Challenge

If you could redo this build challenge, what would you do differently? Be sure to explain why you would do certain things differently.
Let’s Build a House!
Lesson 9
Building Materials

Duration: 1 period

Summary:
Students will work with their project groups to complete a build challenge that focuses on the strength of various building materials. Structures of various materials will be tested to determine which materials are strongest and when various materials would be chosen for a design.

Curriculum Expectations:

Science: Understanding Structures and Mechanisms

Overall Expectations:
2. design and construct a variety of structures and investigate the relationship between the design and function of these structures and the forces that act on them.

Specific Expectations:
2.1 follow established safety procedures for using tools and handling materials
2.2 design, construct, and use physical models to investigate the effects of various forces on structures
2.4 use technological problem-solving skills (see page 16) to determine the most efficient way for a structure (e.g., a chair, a shelf, a bridge) to support a given load
2.6 use appropriate science and technology vocabulary in oral and written communication
2.7 use a variety of forms (e.g., oral, written, graphic, multimedia) to communicate with different audiences and for a variety of purposes

Resources/Materials Needed:
- Hot glue guns (1 per group)
- Scissors (2 per group)
- Rulers
- Toothpick and marshmallow shapes
- Wooden skewers
- Balsa wood strips
- Plastic straws
- Cardboard strips
### Instructional Plan:

<table>
<thead>
<tr>
<th>Time</th>
<th>Outline</th>
<th>Assessment Opportunities</th>
</tr>
</thead>
<tbody>
<tr>
<td>15 min</td>
<td>-Prior to class, the teacher will make a triangle, a square, a rectangle, and a pentagon out of toothpicks and marshmallows (one toothpick for each side and one marshmallow at each vertex to hold the sides together).</td>
<td>-This is an assessment for learning and assesses students’ understanding of strong structural shapes and forces, as was discussed in the previous lesson.</td>
</tr>
<tr>
<td>15 min</td>
<td>-Remind students of the build challenge from the previous lesson and the factors they found to be successful. Show students the toothpick and marshmallow shapes and ask them to discuss which shape they think will be the strongest with a partner, and then with a class. Prompt students to explain their reasoning. Explain that to test which shape is strongest, you will be trying to ‘squish’ the shapes by gently placing a book on top of them. Ask students what force will act on the shapes when this happens (compression). Begin the demonstration. The triangle will be the last shape to ‘squish’ and is the strongest. Remind students of how triangles were used in their structures last lesson.</td>
<td></td>
</tr>
<tr>
<td>15 min</td>
<td>-The teacher will introduce this build challenge by giving each group a set of instructions to build a structure. Each group will have the exact same instructions, so each group will be making the same structure. However, each group will have different materials to build with (wooden skewers, balsa wood strips, plastic straws, cardboard strips). Before starting, brainstorm all of the required safety procedures for this challenge. Make sure to discuss safe ways to cut the materials and how to safely operate a hot glue gun. Display the safety procedures throughout the lesson.</td>
<td></td>
</tr>
<tr>
<td>25 min</td>
<td>Students will be given this time to work together in their groups to design and build</td>
<td>-Teacher observation and anecdotal notes will be</td>
</tr>
</tbody>
</table>
their structure. The teacher will circulate and assist as needed.

10 min - When all structures are complete, the teacher will place various weights on each structure until it collapses. Record the weight each structure was able to support.

15 min - As a class, discuss which materials were strongest and which were weakest. Prompt the class to discuss what factors make a material strong or weak (e.g., density, width of material, etc). Point out that different materials have different purposes (e.g., lightweight materials are not as strong, but can be beneficial when building a hand glider).

Differentiating Instruction:
- Teacher will circulate the room and assist students as is needed.
- Students with fine motor control issues can provide ideas to the group while their group members build it.
Let’s Build a House! – Build Plans

1. Using the material assigned to your group, cut 12 strips that are 10cm each.

2. Using the hot glue gun, glue strips together to create a cube. Each 10 cm strip will be one side of your cube. You should have a structure that looks like this:

3. Using the material assigned to your group, cut 6 strips that are 14.1cm each.

4. Using the hot glue gun, glue one strip diagonally across each face of the cube. When you are done, each face should look like this:
Let’s Build a House!  
Lesson 10  
Work Period - Building Plans  

**Summary:**  
Students will review model homes like the ones often seen in real estate offices. After reviewing the various steps of building model homes, students will work with their project groups to design their build plans. To do this, students must choose an appropriate scale for their model, and then draw the building plans according to their chosen scale.

**Curriculum Expectations:**  
*Science: Understanding Structures and Mechanisms*  
Overall Expectations:  
2. design and construct a variety of structures and investigate the relationship between the design and function of these structures and the forces that act on them.  
Specific Expectations:  
2.1 follow established safety procedures for using tools and handling materials  
2.2 design, construct, and use physical models to investigate the effects of various forces on structures  
2.4 use technological problem-solving skills (see page 16) to determine the most efficient way for a structure (e.g., a chair, a shelf, a bridge) to support a given load  
2.6 use appropriate science and technology vocabulary in oral and written communication  
2.7 use a variety of forms (e.g., oral, written, graphic, multimedia) to communicate with different audiences and for a variety of purposes  

*Mathematics: Number Sense and Numeration*  
Overall Expectations:  
- demonstrate an understanding of proportional relationships using percent, ratio, and rate.  
Specific Expectations:  
- determine, through investigation, the relationships among fractions, decimals, percents, and ratios  

*Mathematics: Measurement:*  
Overall Expectation:  
- report on research into real-life applications of area measurements  
Specific Expectation:  
- solve problems that require conversion between metric units of measure
Resources/Materials Needed:
- Model homes (or pictures of them)
- Class set of *Steps to Building a Model Home* sheet
- Rulers
- Calculators
- Blank paper
- Grid paper

Instructional Plan:

<table>
<thead>
<tr>
<th>Time</th>
<th>Outline</th>
<th>Assessment Opportunities</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 min</td>
<td>- The teacher will remind students of the model homes they viewed at the beginning of the unit. The teacher will show students what these model homes look like as a reminder. The teacher will then hand out the <em>Steps to Building a Model Home</em> sheet, read over the steps with students, and answer any questions they may have. Tell students that they will be working on steps 1 and 2 today.</td>
<td>- Criteria decided on will be used to create the rubric for the model home. This will be an assessment of learning tool.</td>
</tr>
<tr>
<td>15 min</td>
<td>- Before students start on their plans, they need to know how they will be assessed. Give students 5 minutes to discuss important criteria for assessing the model homes with their project groups. After this time, each group can share their ideas with the class. If not raised by students, the teacher should prompt the class to consider their use of an appropriate scale, justification of design choice (strong shapes, discussion of forces), use of key vocabulary, etc. As a class, decide upon the criteria that will be used to assess the model homes. The teacher will then use these criteria to create the rubric that will be used to assess the model homes.</td>
<td></td>
</tr>
<tr>
<td>50 min</td>
<td>- Students will be given the materials they need to start designing their build plans for their model homes. Plans can be drawn on grid paper or blank paper, but rulers must be</td>
<td>- Teacher will conference with each group throughout this process and take anecdotal notes</td>
</tr>
</tbody>
</table>


used and the drawing must be to scale. They will need to refer to their blueprints from Lesson 7, which included the measurements of their house. The teacher will circulate and assist students as needed. Note that more time can be given for students to complete this if needed.

5 min - Refer students back to the Project Outline sheet they received during the first lesson and review what still needs to be done. Calculating cost of the homes will begin next lesson. Remind students that their blueprints will need to be finalized before they can calculate cost.

Differentiating Instruction:
- Students with fine motor difficulties can use software programs to make digital build plans. Alternatively, since only one set of plans is needed for each group, another group member can draw them.
- Groups that are struggling to determine an appropriate scale can consult with the teacher for assistance. Scales that are easier to work with can be suggested for these groups (e.g., 2cm = 1m).

on students’ progress and understanding. This is an assessment for learning tool.
### Sample Co-Constructed Criteria for Model Homes

- Appropriate scale is chosen (so model is not too big or too small)
- Measurements of the model home are to scale
- Design is clear and design choices are justified using their knowledge of structural design factors and of forces
- Follow safety procedures

### Sample Model Home Rubric
(Made Using the Co-Constructed Criteria)

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Level 4</th>
<th>Level 3</th>
<th>Level 2</th>
<th>Level 1</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Appropriateness of Scale</strong></td>
<td>The chosen scale demonstrates a high level of proportional understanding and is appropriate for creating a model.</td>
<td>The chosen scale demonstrates sufficient proportional understanding and is appropriate for creating a model.</td>
<td>The chosen scale demonstrates some proportional understanding and is somewhat appropriate for creating a model.</td>
<td>The chosen scale demonstrates limited proportional understanding and is not appropriate for creating a model.</td>
</tr>
<tr>
<td><strong>Scaled Measurements</strong></td>
<td>All of the measurements are calculated correctly according to the chosen scale.</td>
<td>Most of the measurements are calculated correctly according to the chosen scale.</td>
<td>Some of the measurements are calculated correctly according to the chosen scale.</td>
<td>Few of the measurements are calculated correctly according to the chosen scale.</td>
</tr>
<tr>
<td><strong>Justification of Design</strong></td>
<td>Design choices are justified with a high degree of knowledge of forces and structural factors.</td>
<td>Design choices are justified with sufficient knowledge of forces and structural factors.</td>
<td>Design choices are justified with some knowledge of forces and structural factors.</td>
<td>Design choices are justified with limited knowledge of forces and structural factors.</td>
</tr>
<tr>
<td><strong>Safety Procedures</strong></td>
<td>All safety procedures were followed.</td>
<td>Most safety procedures were followed.</td>
<td>Some safety procedures were followed.</td>
<td>Few safety procedures were followed.</td>
</tr>
</tbody>
</table>
Let’s Build a House! – Steps for Building a Model Home

1. Decide on an appropriate scale for your model home.
   - Remember that the actual measurements for your house were included on your blueprints. Refer to these to determine how big your house will be and use this information to decide on a scale.

2. Draw the frame of the house according to scale.
   - A frame should look similar to the structures we made during the build challenges. It should only include the edges of your model (no interior walls). Remember to include a written description of why you designed the frame the way you did.

3. Build the frame of the house.
   - You will use balsa wood strips and a hot glue gun to do this.

4. Cut your walls from construction paper.
   - Cut construction paper to the necessary size so that it will cover the frame of your house. These papers will act as the walls and the roof.

5. Design the walls.
   - Draw, paint, and/or colour on the construction paper to make it look like a house (include bricks, shingles, front door, windows, etc.). Remember you are only designing the exterior of the house.

6. Attach construction paper to the outside of the frame to look like the walls and roof.
   - You will use a hot glue gun to do this.
Let’s Build a House!
Lesson 11
Calculating Costs

Summary:
Students will have an interior designer come in as a guest speaker. Students will learn about the different costs and upgrades available when a home is being designed. The interior designer will focus on flooring types, as this is a necessary component of students’ project. Students will learn why different materials cost more than others, and will learn how to calculate the cost of flooring.

Curriculum Expectations:

*Mathematics: Measurement*

**Overall Expectation:**
- report on research into real-life applications of area measurements

**Specific Expectation:**
- research and report on real-life applications of area measurements

*Mathematics: Number Sense and Numeration*

**Overall Expectation:**
- demonstrate an understanding of addition and subtraction of fractions and integers, and apply a variety of computational strategies to solve problems involving whole numbers and decimal numbers.
- demonstrate an understanding of proportional relationships using percent, ratio, and rate.

**Specific Expectations:**
- solve multi-step problems arising from real-life contexts and involving whole numbers and decimals, using a variety of tools
- use estimation when solving problems involving operations with whole numbers, decimals, and percents to help judge the reasonableness of a solution
- solve problems involving the calculation of unit rates

Resources/Materials Needed:
- Guest speaker: Interior designer
- real estate websites or pamphlets advertising new homes (with a list of upgradable features)
**Instructional Plan:**

<table>
<thead>
<tr>
<th>Time</th>
<th>Outline</th>
<th>Assessment Opportunities</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 min</td>
<td>-The teacher will show students a real estate website or pamphlet and point out that when you buy a new home, you can often choose to pay for a variety of upgraded features. For example, you can pay for upgraded kitchen cabinets or upgraded flooring. Remind students that they will need to provide different costing options for floor upgrades. Introduce the guest speaker to the students.</td>
<td></td>
</tr>
<tr>
<td>15 min</td>
<td>-The guest speakers (interior designers) will explain their job to the class. They will show the students various rooms they have designed and will discuss the process of choosing items like flooring. When deciding on flooring, you must consider the purpose of the room, how it will look, and the cost. Explain that to calculate the cost of redoing the floor we need to know how much flooring will be needed and the price of the flooring. The interior designer will discuss which types of flooring are cheaper (e.g., laminate) and which are more expensive (e.g., hardwood). They will also provide approximate pricing for the 4 types of flooring that the students may need for their projects (tile, carpet, laminate, hardwood).</td>
<td></td>
</tr>
<tr>
<td>10 min</td>
<td>-As an example, the teacher will demonstrate how to calculate the cost of getting new carpet for the classroom. The first step is calculating the area of the classroom floor (for example, 40m²). If new carpet will cost $34.99/m² then the cost of new flooring is simply 34.99 x 40 = $1399.60.</td>
<td></td>
</tr>
<tr>
<td>10 min</td>
<td>-The guest speaker will then explain that sometimes flooring comes in packs (e.g., laminate flooring may come in a case of</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>-Observation and anecdotal notes of students’ understanding during examples.</td>
</tr>
</tbody>
</table>
approximately 2m²) and it is priced for the entire pack, not just for 1m². In this case, we first need to calculate the unit rate, which is the cost per 1m². The teacher will then explain unit rate and how to calculate it.

25 min - Students will then be given package rates for the different costs of flooring; for example, laminate may come in a package of 2m² for $24.99. These prices can be provided by the interior designer or students can look up prices on a local hardware store’s website. They must then calculate the cost of redoing the classroom floor in tile, laminate, and hardwood. Students should complete this individually as it will be handed in at the end of the lesson.

5 min - Before students hand in their work, the teacher will ask them to put a Traffic Light Dot on the corner of their paper. A red dot means students are confused and need to revisit this topic, yellow means they understand it but need more practice, and green means they are good to move ahead. Students are also welcome to write any questions they have underneath their dot.

-These will be collected and used as assessment for learning. These formative assessments will be returned to students in Lesson 12 with written, descriptive feedback.

- The Traffic Light Dot is a form of self-assessment and is used as an assessment as learning task. Students use it to reflect on their own level of understanding.

Differentiating Instruction:

- The teacher will circulate and assist students as is needed.
- Students working at a lower math level can be given easier numbers to work with (benchmark numbers ending in 5 or 0). Alternatively, they can be given the unit rate instead of calculating it if they require modifications.
Let’s Build a House!  
Lesson 12  
Area of Composite Shapes

Summary:  
Students will learn how to calculate the area of irregular composite shapes by splitting the shape up into shapes of known areas. This knowledge will be used to calculate the area of rooms and hallways, which are often composite shapes.

Curriculum Expectations:  
*Mathematics: Measurement*  
Overall Expectation:  
- report on research into real-life applications of area measurements  
Specific Expectation:  
- research and report on real-life applications of area measurements  
- solve problems involving the calculation of unit rates

*Mathematics: Number Sense and Numeration*  
Overall Expectation:  
- demonstrate an understanding of addition and subtraction of fractions and integers, and apply a variety of computational strategies to solve problems involving whole numbers and decimal numbers.  
- demonstrate an understanding of proportional relationships using percent, ratio, and rate.  
Specific Expectations:  
- solve multi-step problems arising from real-life contexts and involving whole numbers and decimals, using a variety of tools  
- use estimation when solving problems involving operations with whole numbers, decimals, and percents, to help judge the reasonableness of a solution  
- solve problems involving the calculation of unit rates

Resources/Materials Needed:  
- Sample home blueprints with rooms that are composite shapes  
- Calculators

Instructional Plan:  

<table>
<thead>
<tr>
<th>Time</th>
<th>Outline</th>
<th>Assessment Opportunities</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 min</td>
<td>- The teacher will give back the cost calculation work from Lesson 11, with attached written, formative feedback. As students review their</td>
<td>- Students will have a chance to review the written, formative</td>
</tr>
</tbody>
</table>
feedback, the teacher will answer any questions students had about the work and will review any common errors that appeared.

| 10 min | -Referring to sample blueprints of a home, the teacher will pick one room that is not a square, rectangle, or triangle (it needs to be a composite shape). Remind students that before they can calculate the cost of the flooring for this room, they need to calculate its area. The teacher will demonstrate how to decompose the shape into two or more shapes with areas that students can calculate (squares, rectangles, or triangles). Once the area is calculated, calculate the cost of re-carpeting the room assuming carpet can be bought in a 2m² pack for $34.99. |
| 15 min | -The teacher will then assign each project group to a room from the blueprints of a home. Each group will calculate the cost of the carpet for the room. |
| 10 min | -To consolidate, each group will should how they decomposed the room they were assigned into shapes they know how to calculate the area of, the total area, and the cost of carpeting for the room. |

**Differentiating Instruction:**
- The teacher will circulate and assist students as is needed.
- Students working at a lower math level can be given the unit rate instead of calculating it if they require modifications.
Summary:
Students will review the success criteria for calculating costs of flooring and will co-construct the assessment tool that will be used to assess their cost calculations. Students will then be given time to calculate the area and costs of flooring for their homes. Students will need to use their finalized blueprints to calculate the area of each room.

Curriculum Expectations:

*Mathematics: Measurement*

Overall Expectation:
- report on research into real-life applications of area measurements

Specific Expectation:
- research and report on real-life applications of area measurements
- solve problems involving the calculation of unit rates

*Mathematics: Number Sense and Numeration*

Overall Expectation:
- demonstrate an understanding of addition and subtraction of fractions and integers, and apply a variety of computational strategies to solve problems involving whole numbers and decimal numbers.
- demonstrate an understanding of proportional relationships using percent, ratio, and rate.

Specific Expectations:
- solve multi-step problems arising from real-life contexts and involving whole numbers and decimals, using a variety of tools
- use estimation when solving problems involving operations with whole numbers, decimals, and percents, to help judge the reasonableness of a solution
- solve problems involving the calculation of unit rates

Resources/Materials Needed:
- Lined paper
- Calculators

Instructional Plan:

<table>
<thead>
<tr>
<th>Time</th>
<th>Outline</th>
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</tr>
</thead>
<tbody>
<tr>
<td>15 min</td>
<td>-The teacher and students will discuss and</td>
<td>-This rubric will be used</td>
</tr>
</tbody>
</table>
create success criteria for the cost calculations and will co-construct a rubric based on student input. If not brought up by students, the teacher should prompt them to consider adding proper area calculations, accurate unit cost calculations, etc.

100 min -Students will be given this time to work on the cost calculations for the flooring of their house. Students must first calculate the area of each room in their house. Since most rooms are composite shapes, they will need to decompose the room into easier shapes first. Once area is found, students need to calculate the cost of flooring for each room. Remind students that they should refer to their Home Investigation sheet from Lesson 3 when deciding which kind of flooring they want in each room (e.g., tile in a bathroom and not carpet). Students must include all calculations and show all of their work, including how they decomposed the shapes, how they calculated area, how they calculated unit cost for each flooring type (based on prices given last lesson), and how they calculated final cost. The teacher will circulate and assist as needed.

5 min -Review the Project Outline sheet from Lesson 1 and discuss what students still need to complete. As the end of the unit nears, remind students to finish up any steps (blueprints, build plans, cost analysis) that have not been completed, as these will all be used in the next lesson.

as an assessment of learning task at the end of the unit.

-Teacher will conference with students for an assessment for learning to provide feedback and assist when needed. Observations and anecdotal notes will be recorded about students’ progress.

Differentiating Instruction:
- The teacher will circulate and assist students as is needed.
- Students working at a lower math level can be given the unit rate instead of calculating it if they require modifications.
## Sample Flooring Costs Calculation Rubric

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Level 4</th>
<th>Level 3</th>
<th>Level 2</th>
<th>Level 1</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Area Calculations</strong></td>
<td>Area calculations are all correct and demonstrate a high degree of understanding of how to decompose composite shapes.</td>
<td>Area calculations are mostly correct and demonstrate a sufficient understanding of how to decompose composite shapes.</td>
<td>Area calculations are partially correct and demonstrate some understanding of how to decompose composite shapes.</td>
<td>Area calculations are rarely correct and demonstrate a limited understanding of how to decompose composite shapes.</td>
</tr>
<tr>
<td><strong>Unit Rate Calculations</strong></td>
<td>Calculations demonstrate an in depth understanding of how to calculate unit rate.</td>
<td>Calculations demonstrate sufficient understanding of how to calculate unit rate.</td>
<td>Calculations demonstrate some understanding of how to calculate unit rate.</td>
<td>Calculations demonstrate a limited understanding of how to calculate unit rate.</td>
</tr>
<tr>
<td><strong>Cost Calculations</strong></td>
<td>All final flooring cost calculations are calculated correctly.</td>
<td>Most final flooring cost calculations are calculated correctly.</td>
<td>Some final flooring cost calculations are calculated correctly.</td>
<td>Few final flooring cost calculations are calculated correctly.</td>
</tr>
</tbody>
</table>
Let’s Build a House!

Lesson 14
Duration: 2 periods

Peer Feedback and Adjustments

Summary:
Students will peer-review other groups’ projects and will provide written formative feedback for their peers. Groups will review each other’s feedback and have time to make the necessary adjustments.

Curriculum Expectations:

Mathematics: Number Sense and Numeration

Overall Expectation:
- demonstrate an understanding of addition and subtraction of fractions and integers, and apply a variety of computational strategies to solve problems involving whole numbers and decimal numbers.
- demonstrate an understanding of proportional relationships using percent, ratio, and rate.

Specific Expectations:
- solve multi-step problems arising from real-life contexts and involving whole numbers and decimals, using a variety of tools
- evaluate expressions that involve numbers and decimals, including expressions that contain brackets, using order of operations
- determine, through investigation, the relationships among fractions, decimals, percents, and ratios
- solve problems involving the calculation of unit rates

Mathematics: Measurement

Overall Expectation:
- report on research into real-life applications of area measurements

Specific Expectation:
- research and report on real-life applications of area measurements
- solve problems that require conversion between metric units of measure
- estimate and calculate the area of composite two-dimensional shapes by decomposing into shapes with known area relationships

Science: Understanding Structures and Mechanisms

Overall Expectations:
2. design and construct a variety of structures and investigate the relationship between the design and function of these structures and the forces that act on them.

Specific Expectations:
2.2 design, construct, and use physical models to investigate the effects of various
forces on structures
2.4 use technological problem-solving skills (see page 16) to determine the most efficient way for a structure (e.g., a chair, a shelf, a bridge) to support a given load
2.6 use appropriate science and technology vocabulary in oral and written communication
2.7 use a variety of forms (e.g., oral, written, graphic, multimedia) to communicate with different audiences and for a variety of purposes

Resources/Materials Needed:
- Sticky notes

Instructional Plan:

<table>
<thead>
<tr>
<th>Time</th>
<th>Outline</th>
<th>Assessment Opportunities</th>
</tr>
</thead>
<tbody>
<tr>
<td>15 min</td>
<td>-The teacher will inform students that they will be peer-rev... until this point (blueprints, build plans, and cost calculations). Review how to give constructive feedback (be respective, be constructive and not just critical, provide suggestions for improvement). Also remind students to check the assessment tools to make sure the group has included all required parts of the project.</td>
<td>-Engaging in peer assessments is a form of assessment as learning. Students are able to assess each other’s work which makes them more aware of the expectations of the project.</td>
</tr>
<tr>
<td>25 min</td>
<td>-The teacher will give each group a pack of sticky notes on which they can write their feedback, and stick the note onto the applicable work. Each group will be given the work from one other group to review. Depending on how long students take to provide feedback, they may be able to review several group’s work. The teacher will circulate and ensure students are providing appropriate constructive feedback to each other.</td>
<td>-The teacher will conference with each...</td>
</tr>
<tr>
<td>35 min</td>
<td>-Students will return to their own work and read over the feedback they received from...</td>
<td></td>
</tr>
</tbody>
</table>
their peers. Based on this feedback, students will make adjustments to their work and add any missing aspects of the project. Depending on how much feedback students received, they may require more time to complete this step.

5 min

-Remind students that they will be building their model homes next period. Answer any questions students have about the next lesson so that they will be prepared.

**Differentiating Instruction:**

- The teacher will circulate and provide support as is needed.
- Group members can work together to provide feedback.

group and focus on providing feedback on their build plans for next lesson. This formative assessment is an assessment for learning tool.
Let’s Build a House!  

Lesson 15  

Duration: 4 period  

Work Period – Building Models  

Summary:  
Students will first review the safety procedures that they need to follow during this lesson. Students will then have time to build their model homes.

Curriculum Expectations:  

*Science: Understanding Structures and Mechanisms*  

Overall Expectations:  
2. design and construct a variety of structures and investigate the relationship between the design and function of these structures and the forces that act on them.

Specific Expectations:  
2.1 follow established safety procedures for using tools and handling materials  
2.2 design, construct, and use physical models to investigate the effects of various forces on structures  
2.4 use technological problem-solving skills (see page 16) to determine the most efficient way for a structure (e.g., a chair, a shelf, a bridge) to support a given load  
2.6 use appropriate science and technology vocabulary in oral and written communication  
2.7 use a variety of forms (e.g., oral, written, graphic, multimedia) to communicate with different audiences and for a variety of purposes

Resources/Materials Needed:  

- Balsa wood strips  
- Xacto knife  
- Scissors  
- Hot glue gun  
- Rulers  
- Construction paper  
- Coloured pencils  
- Markers  
- Digital cameras

Instructional Plan:  

<table>
<thead>
<tr>
<th>Time</th>
<th>Outline</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 min</td>
<td>-The teacher will begin the lesson by reviewing</td>
</tr>
</tbody>
</table>
the *Steps to Building a Model Home* sheet from Lesson 10. Students will be starting at step 3 today. Discuss each step and where students will find the required materials in the room.

<table>
<thead>
<tr>
<th>Time</th>
<th>Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 min</td>
<td>-Based on the materials being used (hot glue gun, Xacto knives, etc.) have the students come up with a list of safety procedures they will follow. The teacher will have a designated space set up for using the Xacto knives and students may not use this station without teacher supervision. Make sure the list of safety procedures is posted for students to refer to throughout the lesson.</td>
</tr>
<tr>
<td>125 min</td>
<td>-Students will have time to work with their group members to build their model home. They will first cut the wood to the correct length and glue it together according to their build plans to make the frame of the house. They will then cut construction paper to make the walls, decorate it accordingly, and glue it onto the frame. The teacher will be at the Xacto knife station when needed, and will otherwise be circulating the room assessing students' ability to follow safety procedures. If needed, these periods can split up over a few days.</td>
</tr>
<tr>
<td>20 min</td>
<td>-When students are finished building, they will clean up all materials they used. Students will then take photos of their finished model home with a digital camera. These photos will be used next lesson in their advertising pamphlets.</td>
</tr>
</tbody>
</table>

-Teacher observation will be used to ensure students are following their build plans and all safety procedures. These observations will be used as an assessment of learning and will be recorded on the group's *Model Home Rubric*.

**Differentiating Instruction:**
-Students will share responsibilities between their group members.
-The teacher can assist students as needed.
Let’s Build a House!  Lesson 16
Duration: 2 periods

Work Period – Advertising Pamphlets

Summary:
Students will review the Pamphlet Checklist they created in Lesson 2 and discuss the criteria for making an effective advertising pamphlet. Students will then work with their groups to create an advertising pamphlet for the house they have designed.

Curriculum Expectations:

*Language: Media Literacy*

**Overall Expectation:**
1. demonstrate an understanding of a variety of media texts
3. create a variety of media texts for different purposes and audiences, using appropriate forms, conventions, and techniques

**Specific Expectations:**
1.1 explain how various media texts address their intended purpose and audience
3.3 identify conventions and techniques appropriate to the form chosen for a media text they plan to create, and explain how they will use the conventions and techniques to help communicate their message
3.4 produce a variety of media texts of some technical complexity for specific purposes and audiences, using appropriate forms, conventions, and techniques

Resources/Materials Needed:
- Digital cameras
- Computers
- Printer

Instructional Plan:

<table>
<thead>
<tr>
<th>Time</th>
<th>Outline</th>
<th>Assessment Opportunities</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 min</td>
<td>- The teacher will show students the Advertising Pamphlet Checklist that they co-constructed in Lesson 2. The class will discuss the important features of an effective advertising pamphlet and they will read over the rubric that the teacher created based on the checklist. The teacher will answer any questions students have about creating their pamphlets.</td>
<td></td>
</tr>
</tbody>
</table>
### Differentiating Instruction:

- Groups may use a pamphlet template (available on the computer) if needed.
- The teacher will assist students as needed.
- Speech to text programs can be used if required.
### Sample Advertising Pamphlet Rubric
(Based on the *Sample Advertising Pamphlet Checklist*)

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Level 4</th>
<th>Level 3</th>
<th>Level 2</th>
<th>Level 1</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Important Information</strong></td>
<td>Pamphlet includes all of the important information that homebuyers would want to know.</td>
<td>Pamphlet includes most of the important information that homebuyers would want to know.</td>
<td>Pamphlet includes some of the important information that homebuyers would want to know.</td>
<td>Pamphlet includes little of the information that homebuyers would want to know.</td>
</tr>
<tr>
<td><strong>Target Audience</strong></td>
<td>Pamphlet is highly effective at addressing the intended purpose and audience.</td>
<td>Pamphlet is effective at addressing the intended purpose and audience.</td>
<td>Pamphlet is somewhat effective at addressing the intended purpose and audience.</td>
<td>Pamphlet is not effective at addressing the intended purpose and audience.</td>
</tr>
</tbody>
</table>
Let’s Build a House!

Lesson 17

Summary:

Students will participate in a showroom event to present and celebrate their projects. Other classes, families, and relevant audience members (interior designers, etc.) will be invited to attend. Each group will have the chance to present all of their work and model homes, as if they were real estate agents selling the property.

Curriculum Expectations:

- All expectations from the unit will be demonstrated and evaluated during this lesson.

Resources/Materials Needed:

- Guests (other classes, families, friends, prior guest speakers, etc.)
- Partially completed KWL Charts from Lesson 1
- Two Stars and One Wish self-assessments

Instructional Plan:

<table>
<thead>
<tr>
<th>Time</th>
<th>Outline</th>
<th>Assessment Opportunities</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 min</td>
<td>The teacher will welcome any guests who have attended and will give them a summary of the project that students have been working on. During this time, students can set up and prepare for their presentations.</td>
<td>- All work that is submitted after the presentations will be assessed using the various rubrics that have been created with the students throughout the unit. These will be assessments of learning and will make up students’ final marks for this unit.</td>
</tr>
<tr>
<td>100 min</td>
<td>Each group will have 10-15 minutes to present their project. This is their chance to really “sell” their home to the audience, who would be “potential buyers”. Students should be sure to show their model home, discuss how they designed it, and any other information they included in their advertising pamphlets. Audience members will have the chance to ask questions and provide feedback for each group. After their presentations, students will submit all work (blueprints, cost calculations, build plans, model home, and...</td>
<td></td>
</tr>
</tbody>
</table>

Final Showroom
- Students may choose to present in a way that suits their learning style. They can do a verbal presentation, make a short video, use a PowerPoint presentation, etc.
Let’s Build a House! – Two Stars and One Wish

Two things I did well during this project were:

One thing I could have improved on was:
CHAPTER FIVE: SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Mathematics is one subject that many students struggle to find meaningful connections with and, therefore, some students report finding the study of mathematics boring (Uyangor, 2012). This is often the case for students who are taught through traditional mathematics teaching strategies including heavy reliance on textbook work and drill practices (Uyangor, 2012). To combat these negative views of mathematics, teachers need to find engaging ways to connect students with mathematics in a more meaningful, relatable manner. PBL is one proposed method of achieving this because of its student-centred approach and its focus on real-world applications of curriculum content. However, there has been some confusion between PBL and traditional school projects, and the specific implementation of PBL is not always clear (Larmer & Mergendollar, 2010).

This curriculum unit was developed to be a guide for educators seeking to implement PBL in their own mathematics class. The unit’s focus on real-world applications and a variety of practical activities aims to create meaningful, enjoyable learning experiences for students as they learn about mathematics and other subjects.

Summary

The current focus of mathematics education in Ontario has shifted from content knowledge to become more focused on mathematics process skills and real-world problem solving applications (Ontario Ministry of Education, 2005). PBL has the potential to make mathematics education more meaningful for students by engaging them with real-world problems, but the lack of understanding among educators about how to effectively implement PBL may be preventing them from providing these kinds of
learning opportunities to students (Larmer & Mergendollar, 2010). This curriculum unit was designed using PBL principles to assist educators who would like to implement PBL into their own classes. The curriculum unit was developed using the backwards design model, whereby the planning process began with consulting the Ontario grade 7 curriculum documents and designing a culminating project to assess the chosen curriculum expectations from mathematics, science, and language. Ongoing assessments and lessons were then planned so that they built upon each other and prepared students for their culminating project. Lessons were designed to scaffold students towards their culminating task by teaching the knowledge and skills students would need to complete the final project.

The lessons, learning activities, and assessment tasks included in this unit were specifically designed to have clear connections to real-world applications. This was an important aspect of the unit because studies have shown that when learning has clear connections to real-world applications, as it does in PBL, students report learning to be much more enjoyable and engaging (Larmer & Mergendollar, 2010). Further, hands-on learning experiences in PBL have been shown to increase students’ attitudes towards mathematics and their motivation to learn (Karacalli & Korur, 2014); therefore, many of the lessons in this unit include practical, hands-on activities.

Since one of the purposes of creating this curriculum unit was to provide a guide for educators who are learning how to implement PBL, the unit plan includes all of the eight key features of PBL, as were outlined by the Buck Institute for Education (n.d.), a leader in PBL research and information. These features include significant content, a need to know, a driving question, student voice and choice, 21st century competencies, in-
depth inquiry, critique and revision, and a public audience.

Due to the high level of student input that is required to make PBL as student-centred as possible, this curriculum unit was created to be flexible enough for teachers to modify as needed. Timelines provided in the unit plan are suggestions that may need to be adjusted according to students’ needs. Additionally, all assessment tools and success criteria are to be co-constructed by the students and the teacher, although sample tools are included in the unit to provide educators with examples of what they should be working towards. Providing students with choices and input in their learning process is one of the benefits of PBL that has been linked to increased enjoyment, engagement, and motivation (Grant, 2002) and, as such, was an important aspect to model in this unit.

**Conclusion**

This curriculum unit was designed to be a tool used to assist teachers to further their understanding of PBL and to be a guide of how PBL can be effectively implemented in an integrated classroom setting. The lessons and learning activities were created to show educators how to engage students with relevant learning tasks and how to provide students with meaningful connections between mathematics and the real world.

This unit aimed to teach not only subject knowledge, but also to assist students in the development of 21st-century skills such as collaboration, effective communication, and problem solving. These transferable skills are highly valuable to students because they are transferable skills that can be used in other educational tasks and in students’ everyday lives. Hopefully, this project can be used by educators and assist them in creating engaging and meaningful learning opportunities for students in the future.
**Recommendations**

The way mathematics is taught in schools must continue to shift away from traditional methods and towards student-centred approaches in order for students to develop positive attitudes towards the subject. Today’s students find traditional mathematics instruction boring with its overreliance on textbooks and preference for simple rote tasks (Uyangor, 2012). The Ontario Ministry of Education (2005) calls for mathematics instruction to emphasize the process skills behind calculations and to promote problem solving and higher-level thinking. While PBL certainly achieves these goals by engaging students in collaboratively creating projects to solve real-world problems, there are undoubtedly many other student-centred teaching strategies that can achieve similar means. Further research is needed to explore alternative student-centred teaching strategies that can be used to make mathematics more enjoyable and relatable to students.

However, one of the barriers that exists in preventing teachers from adopting more student-centred teaching approaches is the teacher’s attitude towards mathematics instruction. If PBL and other similar styles of instruction are to continue gaining popularity, teachers must be willing to move away from the traditional teacher-centred approach and pass some control over to students. Park-Rogers et al. (2010) found that teachers who were very content-focused and those who were reliant on traditional teaching strategies faced many challenges when attempting to implement PBL and these teachers were more likely to give up on PBL and revert to their old teaching strategies. Conversely, educators who were willing to become facilitators of student learning and those who strived to teach 21st century skills instead of focusing on computation skills
were more likely to value PBL and continue using it effectively. Further, teachers who believed in traditional mathematics instruction were more likely to dismiss some of the most beneficial aspects of PBL such as student collaboration (Wood & Chapman, 2004). These studies demonstrate that before PBL can be accepted and implemented on a wide scale, teachers must first be open to changing their teaching style. Teachers trying to adopt PBL should also be given professional development support along the way.

Even if teachers are willing to implement PBL, there are conflicting views on what constitutes PBL and how it should be implemented (Yetkiner et al., 2008; Zafirov, 2013), which can make attempting PBL daunting for first-time users. Pre-made curriculum units, such as the one created for this project, can play an important role in assisting teachers in their transition into this kind of teaching style. Therefore, research into developing more pre-made PBL units would be extremely beneficial for educators who are trying to use PBL for the first time. Providing educators with these PBL unit templates and guidelines would help make their transition into PBL easier. It would be important for there to be pre-made units for different grade levels, from primary to secondary, since the implementation of PBL needs to adjust according to the age and ability level of the students involved.

Mathematics education consists of so much more than computations. Effective mathematics education is engaging for students; it is meaningful to their lives, and it aids in the development of transferable process skills. The thinking processes and the 21st century competencies that students learn in mathematics are skills that will assist them in both educational tasks and in their daily lives. However, students will not learn these transferable, higher-level thinking skills through rote memorization of mathematics facts,
nor will they learn these skills by answering computational questions that have no connection to the real world. If we are trying to prepare our students to be successful, we need to use student-centred, 21st century teaching strategies to do so.
References


Larmer, J., & Mergendoller, J. R. (2010). Main course, not dessert: How are students reaching 21st century goals with 21st century project based learning?


