Outdoor Play-Based Number Sense and Numeration Experiences for Primary Levelled Students

A Portfolio Completed in Partial Fulfillment of the Requirements of the Degree of Master of Education

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Portfolio Package Introduction

Classroom educators have a great deal of responsibility beyond the generally understood career description of delivering lessons. As educators are creating well thought out lessons that are differentiated to meet the needs of students, they must also keep up with on-going school community initiatives as well as craft delicately worded report cards. The purpose of this Portfolio Package is two-fold. As mentioned, educators are often bombarded with multiple, and often competing school initiatives. A commonly heard initiative is to enhance traditional classroom learning by utilizing outdoor activities and resources. This Portfolio Package first serves the purpose to be a resource for educators to quickly locate inspiration for play-based mathematical experiences. Secondly, this document serves the purpose to support, and motivate educators who are feeling nervous or overwhelmed by the thought of bringing students outdoors.

This Portfolio Package includes an Annotated Bibliography that comprises of critically analyzed peer-reviewed journal articles and published texts. Each annotation takes into consideration the benefits and potential outcomes of outdoor play-based lessons. Articles that challenge outdoor play-based experiences are also analyzed. The second component of this package is the Practical Resource Guide. Within the Practical Resource Guide, there are five sections that include several number sense and numeration learning experiences, assessment opportunities, and academically supported documentation of the positive outcomes that students will experience.

Going beyond the comfort zone of traditional classroom spaces can be daunting. Educators must consider the practicality and the academic components of moving beyond the school walls. Considerations may include, ensuring that students are dressed seasonally appropriate, as well as delivering lessons that are authentic and assessable. The goal of this Portfolio Package is to eliminate an obstacle educators face when considering outdoor experiences. As described within the Portfolio Package, the benefits of these outdoor learning experiences are too great to ignore.

Creating The Outdoor Number Sense and Numeration Practical Guide

The creation of this Portfolio Package to fulfill the requirements of completing Lakehead University's Masters of Education Portfolio Program has been a culmination of a fourteen-month period. Initially, when embarking on the Master's Program, the intention was to fulfill the requirements to complete the course-route option. However, through employment opportunities and insights learned within course work I felt compelled to create a portfolio document.

The most difficult aspect of creating this document was solidifying the direction of study. After numerous brainstorming sessions, the topic of outdoor-based education became a recurring theme. At this time I was also hired by The Oro-Medonte Forest School. While being a Forest School Educator, the benefits and opportunities that are presented within the natural environment were witnessed first-hand. Although the learning experiences within the Practical Resource Guide were developed when I was a Forest School educator, the various learning experiences presented within this document have been tested and altered to best suit an educator within a traditional brick and mortar school setting.

Once the topic of study was solidified, the research process began. Several academic journals were then assessed to ensure that this portfolio was a worthwhile venture and that there was a need for documents of its kind within the academic community. This was based on citing several documents with supported claims that the inclusion of outdoor academics into daily routines improves student performance and attitude towards learning. An Annotated Bibliography was created to catalogue and critically analyze cited documents that both highlight and challenge outdoor academic initiatives.

Upon approval of the Annotated Bibliography, learning experiences began to take shape and culminated in the creation of the practical resource guide. These learning experiences have evolved from personal endeavours as a Forest School educator and from referencing published texts. To ensure the quality of the learning experiences included within the Practical Resource Guide, each has been facilitated within an education setting and altered to best suit the needs of this document. Within this experimentation phase, notes were taken on group management and material tips. These notes have been included within the Practical Resource Guide. To ensure academic suitability, each experience is accompanied by assessment opportunities and a description of what mathematics the students are intended to learn or practice. These sections make reference to the resources contained within the Annotated Bibliography.

The final phase of creating this document has included formatting and editing to prepare the package to be submitted for review by the supervisor, committee member, and finally the chairperson. This entire process has been a journey that has tested my determination and dedication to this document and the Masters of Education Program. Although it is a relief to be approaching the final phases of this process, gratitude is sincerely felt for this adventure.

Positioning the Author

Kirsten has a Diploma in Recreation and Leisure Services from Fanshawe College as well as a degree in Community Recreation with a minor in Political Science from Brock University. She completed her Bachelor of Education through Lakehead University, finishing with First Class Standing. This Practical Portfolio is the final phase of Kirsten's Masters of Education program.

The author has had experiences being a Forest School Educator and a Forest Discovery Programs Coordinator. Currently, Kirsten is a Kindergarten Educator at Royal Oak Community School in Niagara-on-the-Lake. Within weekly routines, the author spends dedicated time in the outdoors with her students. During these practices, Kirsten engages in free play and instruction with the learners.

Kirsten finds great joy in being active in the outdoors as well as being a steward of the environment. She has two cats and one dog and currently resides in Fenwick, Ontario.

Using this Document

It is intended that reviewing the following learning experiences allows for opportunities to use them spontaneously throughout the day. These learning experiences can be planned for, or a part of a teachers' toolbox. For example, while lining up, or in a gathering circle, a student makes mention that five students are wearing rubber boots and the rest are in running shoes. The teacher can then ask, "Is there a way we could show this using our bodies?' Or, while at play, if there are a group of students are watching cars drive by the school, ask if there is a way they could keep track of the cars. These examples connect to the 'everything counts' learning experience and how there are always opportunities to make connections to the curriculum.

This Portfolio Package has used the Ontario Mathematics Curriculum's (Ontario Ministry of Education, 2005) definition of Number Sense and Numeration as its guide. The curriculum document defines Number Sense and Numeration as a general understanding of number and operations as well as the ability to apply this understanding in flexible ways to make mathematical judgements and to develop useful strategies for solving problems. My experiences as an educator suggest that students do not grasp all of these relationships automatically. A broad range of activities and investigations, along with guidance by the teacher, will help students construct an understanding of number that allows them to make sense of mathematics and to

know how and when to apply relevant concepts, strategies, and operations as they solve problems. (Ontario Mathematics Curriculum, 2005, p. 8).

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Chapter Two: Literature Review

Annotated Bibliography

The world which educators are preparing students for is evolving from one day to the next. Boaler (2015) claims that it is impossible to know what mathematics our students will need in the future, but that the best preparation is to develop their mathematical ideas and to help them think in a flexible way, promote problem-solving, and encourage them to be creative. This pedagogy can be adapted to teach mathematics within outdoor, play-based learning experiences. Outdoor, play-based learning experiences for mathematics help to create foundational knowledge needed to progress through later years of mathematics education but to also assist students in creating links to real-life applications of mathematics. Mathematics is important not only for being a part of the workforce but also in daily life (Ferguson, 2012). When students experience these direct links between their mathematics education and real-life scenarios they have a greater investment in their learning and experience personal growth and academic success.

The goal of the Annotated Bibliography presented below is to analyze the literature which argues that outdoor play-based mathematics experiences can be beneficial for primary leveled students' foundational knowledge, in particular number sense and numeration. The purpose of this Annotated Bibliography was to develop a portfolio of practical provocations and tools for kindergarten and primary-levelled educators to use within their teaching practice. The literature sources that have been selected for the bibliography promote the pedagogy of outdoor play-based learning experiences, as well as highlight the lack of research completed within Canada in regard to outdoor play-based mathematics experiences and academic achievement. Each annotation includes discussion about the merit and relevance for the Practical Resource Guide.

Annotated Bibliography

Ailwood, J. (2003). Governing early childhood education through play. *Contemporary Issues in Early Childhood, 4*(3), 286-299. doi:10.2304/ciec.2003.4.3.5

The purpose of Ailwood's (2003) article is to challenge how play has been incorporated in early childhood education and to identify the practices and strategies that educators use to maintain the use of play (p. 287). To achieve this goal Ailwood (2003) presents a series of studies on the concept of play and how it relates to early childhood development and education. The intention of the article of challenging in the inclusion of play within a structured education environment is often lost within the analysis of the studies presented. It is difficult to sort through the theory and discourses on play to determine whether the author is trying to support or refute the use of play-based learning. This article has not been referred to or used in the Practical Portfolio.

Ashbrook, P. (2017). The early years: taking math outside. *Science and Children, 54*(9), 118-119. doi:10.2505/4/sc17_054_09_18

Ashbrook (2017) focuses her publication on mathematical learning experiences for early learners in the outdoors. The author explains that the outdoor environment offers several opportunities for students to see that math exists at home, school, and on the way to and from school (Ashbrook, 2017). Of particular interest to the development of the portfolio, is the way young children have the tendency to collect items they find on outdoor exertions. Ashbrook (2017) explains that the habit of collecting is a critical developmental moment for young children because it creates learning opportunities for counting, grouping, and ordering (Ashbrook, 2017, p. 118). Collecting items can be related to Jean Piaget's logico-mathematical theory of childhood development (Ashbrook, 2017, p. 118). Allowing students to freely explore the natural environment gives them opportunity to practice collecting behaviours. "Connecting children to nature while growing their math skills will prepare them for a future where they will problem-solve, construct, and understand the complex relationships needed to guide humanity to a sustainable future" (Ashbrook, 2017, p. 119). The foundation of understanding complex relationships begins with the counting, grouping, and ordering of collected materials.

Although this document is brief, it provides ample information in regard to childhood development. Ashbrook's (2017) article is relevant in terms of its recent

publication as well as its research to support outdoor learning experiences for young children.

Barker, J. (2015). ***The fearless classroom: A practical guide to experiential learning environments.*** **New York: Routledge.**

Barker (2015) focuses on how educators can take risks within their teaching practice to enhance the learning experiences of the students. This risk-taking approach is centred on the philosophy that teachers must let go of being the sole provider of information and that all activities should allow for practice and experiences (Barker, 2015, p. 2). Barker argues, "there is much research to show that discovery activities and challenging problem-solving activities that require collaboration and communication between students are more powerful in creating deeper learning than passive, consumptive activities" (p. 2).

For the purposed of the Practical Resource Guide, the most valuable piece of information coming from Barker's (2015) book is how lessons plans are described. Barker (2015) describes lessons plans not as a roadmap to classroom operations, but as a tool for educators to use to create objectives while keeping outcomes in mind (p. 49). Within this description of a lesson plan is a rotational set up for mathematics centres. These promote practice of concepts learned, experimentation and application within the form of problem-solving tasks (Barker, 2015, p.16). The creation of mathematics centres has influenced the direction of the Learning Experiences that have been created within the Practical Resource Guide.

Benanson, C., & Killion, J. (2001). Moving math outdoors. ***Green Teacher, 64*****, 31.**

Benanson and Killion (2001) illustrate the practical applications and benefits of using the natural environment for mathematics instruction.

A schoolyard is a convenient setting for many math activities and is especially suited to concept application and problem-solving. As well as number sense, patterns and relationships, measurement, estimation, geometry, statistics, and probability- mathematics are, at its root, a way of describing the world and its patterns (Benanson & Killion, 2001, p. 31).

This article also highlights the personal growth opportunities created for students while participating in outdoor instruction, in particular, developing self-confidence in their mathematical abilities.

Benanson and Killion (2001) also bring to light the challenges that may be faced by educators in terms of using the outdoors as a learning space. The main challenge that the authors identify is that no two schoolyards are the same. With no two schoolyards being the same, influences the creation of a Practical Resource Guide that can be adapted to different outdoor spaces, weather climates, as well as urban and rural considerations. This article comes from a reputable and well-known publication; therefore, it can be considered a reliable source.

Bonner, E. (2014). Investigating practices of highly successful mathematics teachers of traditionally underserved students. ***Educational Studies in Mathematics,*** **3, 377. doi:10.1007/s10649-014-9533-7**

Similar to the Barker (2014) document, Bonner's (2014) article focuses primarily on educator professional development within the classroom environment. Bonner (2014) describes how teachers have the platform to create learning environments which cater to learner needs based on culture, place, language and other socially constructed factors (p.380). Teacher interactions with students, which are social and therefore culturally significant, have an impact on student identity development and perceived ability in mathematics (Bonner, 2014, p.380). "Constructs of mathematical knowledge and on individuals' relationship to math are highly interpretive and are influenced greatly by the individual's experience with mathematics, many of which are framed by teachers" (Bonner, 2014, p.380). A student's relationship with mathematics may also be influenced by the physical learning environment created by the educator. The creation of constructs and student relationships with mathematics can be used as justification for utilizing the outdoor environment for creating mathematical experiences for students. As supported by Bonner, teachers are responsible for framing experiences for their students to develop mathematical knowledge. When educators cater to their students' cultural needs for a sense of place, in particular, there is a greater opportunity for student success.

This document is not directly related to the Practical Portfolio of creating outdoor play-based mathematical experiences, however; it does provide rationale for the document. Primarily, the key message is that there is more to mathematical instruction than rote practice, there are socially constructed influences that educators also need to consider.

Davies, R., & Hamilton, P. (2018). Assessing learning in the early years' outdoor classroom: examining challenges in practice. *Education, 46*(1), 117-129. doi:10.1080/03004279.2016.1194448

The intention of Davies and Hamilton's (2018) article was to focus on the gap in the literature associated with understanding educators' experiences with assessing student learning in the outdoors. The article is based on a qualitative study completed in which ten educators were interviewed and were asked about their experiences with assessment while in the outdoor environment. Among the interviewees, most shared that their experiences were similar to assessing students indoors but they faced challenges based on policy and curriculum mandates (Davies & Hamilton, 2018, p. 124). These challenges stemmed from the inability to truly assess a child's personal development in social contexts, such as independence, when following curriculum mandates that had traditional focuses. The interviewees also shared that with standardized testing, more focus needs to be put on rote math rather than exploratory mathematical development (Davies & Hamilton, 2018, p. 126).

Throughout this article, there are peer-reviewed references that support the benefits of outdoor learning environments and the authors appear to support the pedagogy. However, the authors do acknowledge that this type of pedagogy does come with a variety of hindrances. Davies and Hamilton (2018) have provided some insight into the process of creating experiences as a whole. The insight of creating an experience as a whole package, has influenced the Practical Resource Guide to include assessment tools and strategies.

Din, S. (2016). Outdoor mathematics education: Using outdoor environments to deepen students' understanding of mathematical concepts. *Pathways: The Ontario Journal of Outdoor Education, 29*(1) 16-19

The article *Outdoor Mathematics Education: Using Outdoor Environments to Deepen Student's Understanding of Mathematical Concepts* focuses on how using an outdoor environment can help with improving student mathematical achievement. Although other articles cited within this annotated bibliography focus on socio-emotional benefits of outdoor education, the Din (2016) article highlights academic achievements

associated with outdoor learning. According to Din (2016), the increase of academic achievement associated with outdoor instruction can be attributed to the real life scenarios created in the natural environment and because students can begin to see that math is all around them (Din, 2016, p. 16). “This may also help to ease, and perhaps eliminate, students’ anxieties toward math because outdoor math education can dispel the misconception that math is only about numbers, procedures and solving irrelevant problems” (Din, 2016, p.16). Din (2016) also includes practical suggestions for using the outdoor environment for mathematical instruction. An example that Din (2016) suggests is going to ‘math walks’ to collect, gather, estimate and identify.

Din’s (2016) article comes from a trustworthy article published in Ontario. Including an article published in Ontario is especially noteworthy because most of the literature found about outdoor education is published in European education journals. Referencing Ontario published materials is also beneficial because this Portfolio Package has been created in Ontario, using the Ontario curriculum documents as its guide.

Ferguson, C., Mink, D., & Wetzel, B. (2012). Number sense: Strategies for helping preschool through grade 3 children develop math skills. *YC Young Children,* (3), 89.

Ferguson, Mink, and Wetzel (2012) focus their article on academic achievement in mathematics within the United States. The authors make reference to the fact that even though achievement has increased since the No Child Left Behind Act of 2001, there is still evidence to show that American students are falling behind the global community in regard to mathematical achievement (Ferguson, et al., 2012, p. 89). With this information, the authors (2012) use their platform to support early development of number sense and numeration. “The importance of number sense cannot be overemphasized” (Ferguson, et al., 2012, p. 90). Within this article, and within the Practical Portfolio, number sense and numeration is defined as an “ability to immediately identify the numerical value associated with small quantities, a facility with basic computing skills, and a proficiency in approximating the magnitudes of small numbers of objects and simple numerical operations” (Ferguson, et al., 2012, p. 90). The authors (2012) suggest that with early preparation within kindergarten and primary number sense and numeration, students will have the tools to succeed in more advanced forms of mathematics.

This article does not relate to outdoor play-based mathematics, but it does support the importance of number sense and numeration development. Highlighting the importance of number sense and numeration is valuable justification for the creation of a practical portfolio of number sense and numeration experiences.

Gifford, S. (2004). A new mathematics pedagogy for the early years: in search of principles for practice. ***International Journal of Early Years Education, 12*****(2), 99-115. doi:10.1080/0966976042000225507**

Similar to most of the articles included in this annotated bibliography, Gifford (2004) gives insight into England's approach to alternative mathematics pedagogies. This article is intended for educators for early year centres, but still holds value for the practical portfolio. Gifford (2004) discusses early childhood development theories on how children aged three to five learn best, by examining cognitive, social, emotional, and physical aspects of learning.

Within the document, Gifford (2004) provides ample practical strategies for educators to enhance the learning experiences for students. There are also many references to how the outdoor environment helps with the attainment of multi-sensory learning situations (Gifford, 2004, p. 105). In addition to using the outdoors, Gifford (2004) puts an emphasis on young children's need for physical action and gross motor movement within learning experiences (p.104). An example of including physical action and gross motor movement into learning experiences would be using a sidewalk as a number line.

There are several references within the Gifford (2004) text that support the findings within the contents of this annotated bibliography. Having an abundance of peer reviewed support is indicative of the need for practical resources as well as the importance of expanding mathematical teachings beyond the rote teaching strategies to an exploratory approach.

Humberstone, B., Prince. H., & Henderson, K. A. (2016) ***Routledge international handbook of outdoor studies.*** **Abingdon, UK: Routledge.**

The *International Handbook of Outdoor Studies* is a massive text which has offered some guidance in the practice of outdoor based mathematics. The most striking

statement was that more research is needed to focus on how and why outdoor learning is important for specific outcomes (Humberstone, Prince & Henderson, 2016, p. 110).

This has been made clear, in particular with the quantitative studies completed in Canada to measure the academic success rate of students who participate in outdoor play based learning. Much existing research makes claims for relatively global benefits, but drilling down to associations between certain features of learning environments and specific outcomes will help us to create more nuanced understandings of what sorts of outdoor places and pedagogy will support what kinds of outcomes, and help us to construct well-balanced curricula, environments and pedagogy for young children.

(Humberston, et al., 2016, p. 110).

The Humberston et al. (2016) text defend the use of an outdoor environment throughout a student's time within the education system. Situations experienced in the outdoors cannot be replicated in an indoor classroom environment (Humberston, et al., 2016, p. 115). This is a valuable justification for why it is important to create the Practice Resource Guide of learning experiences for the outdoors. The *International Handbook of Outdoor Studies* is a fascinating text that highlights the importance of including purposeful time in the outdoors.

Isenberg, J. P., & Quisenberry, N. (2002). Play: Essential for all children. (A position paper of the Association for Childhood Education International). *Childhood Education,* (1), 33.

The Isenburg and Quisenberry (2002) article examines the role of play in childhood development. The authors (2002) defend the use of play within the education setting using the Association for Childhood Education International as their primary source of information. It is documented in the Isenburg and Quisenberry (2002) text that play is a crucial part in the growth, learning and development of children from infancy through adolescence (p. 1). The authors also use research on the brain to support the use of play within education settings. For example, they state

Active brains make permanent neurologic connections critical to learning; inactive brains do not make the necessary permanent neurological connections. Research on the brain demonstrates that play is a scaffold for development, a vehicle for increasing neural

structures, and a means by which all children practice skills they will need in later life. (Isenburg & Quisenberry, 2002, p. 2).

This statement further supports many of the research articles within this bibliography which argue when children are active participants in their learning, they have greater opportunity to create connections and develop their understanding.

The authors (2002) have also defined the role that play holds for the primary target for the practical portfolio. In primary grades, children play informal and formal games with their peers and through riddles, number games, and secret codes and messages, children practice and demonstrate their growing understanding of work meanings, letter meanings and numbers (Isenburg & Quisenberry, 2002, p. 5).

This document has been a valuable source for defining play and the role it plays in childhood development but also within an education setting. The concepts presented in this text help to justify the need for play-based learning experiences within primary leveled grades and thus the need for a practical portfolio of play-based resources.

Keith, L. (2018). ***Developing young children's mathematical learning outdoors: linking pedagogy and practice.*** **New York: Routledge.**

The Keith (2018) text is a valuable resource that links the use of outdoor, play-based experiences with mathematical development in young children. Keith (2018) strongly endorses throughout the entirety of the book that outdoor, play-based experiences allow for children to explore, building resilience, being active, and being engaged in the learning process, making decisions, making connections, develop thinking skills, and practice creativity (p. 3). All of these skills and dispositions are central to developing young children as mathematical thinkers and learners (Keith, 2018, p. 3). This book also emphasizes the use of play within outdoor learning. The need to incorporate play into mathematics promotes foundational for young children, especially in practicing counting skills (Keith, 2018, p. 4).

This text has been pivotal in the creating the direction of this portfolio. Prior to reading this text, the focus was on creating 'activities' rather than 'experiences'. However, Keith (2018) suggests creating experiences, instead of activities because experiences allow for more child-led learning with deeper thinking involved than an

> activity, which may still be rich in learning but have the possibilities of being highly planned with a very definite outcome in mind (Keith, 2018, p. 5).

There are links between young children's schematic patterns of behaviour in what they play with and how they play with it repeatedly and early mathematical development. Therefore, the need to consider how the experiences we offer outside can support and enhance the quality of experiences we offer indoors for this type of learning to continue (Keith, 2018, p. 7)

This texts also offers support for using the outdoors as the classroom for mathematical experiences. Keith (2018) describes the outdoor environment as a place where students are able to practice sorting, matching, collecting information, problem-solving, finding patterns and shapes, and using positional language (p. 13).

Keith's (2018) text has been a valuable resource throughout this journey and will be referenced consistently when creating a practical resource. The book has offered guidance through the use of referenced publications and anecdotal evidence from teachers who follow this approach. A fascinating addition to this text, along with many others referenced within this annotated bibliography, is the geographical location of the publications. Many of the sources used have been from Europe, primarily the United Kingdom. The use of sourced materials primarily from United Kingdom demonstrates the gap in Canadian literature in regard to outdoor play-based education. The lack of Canadian literature endorsing outdoor play-based education may be due to the difference in education systems and curricula.

McGrath, C. (2010). S*upporting early mathematical development: practical approaches to play- based learning.* New York: Routledge.

This document, written by McGrath (2010) provides a solid blend between theory and practice. McGrath (2010), goes into detail about different modes of play and how they promote social and academic development in early childhood. One particular mode of play that McGrath (2010) references is multi-sensory play. Multi-sensory play experiences are the most sought by educations (McGrath, 2010, p. 20). This form of play encourages dialogue between the student and materials to flourish, inspiring the students to participate in play in an imaginative way, which is most conducive for mathematical thinking and reasoning (McGrath, 2010, p.20).

Within the acknowledgements at the beginning of the text, McGrath (2010) suggests to the readers to keep a blank page of paper with a pencil to keep a record of their thoughts and reflections. I found this was necessary while going through the text because this book has pushed the boundaries with what it means to play within an education setting and was valuable in creating the Practical Resource Guide.

O'Brien, L. (2009). Learning outdoors: The forest school approach. *Education 3-13, 37*(1), 45-60. doi:10.1080/03004270802291798

The O'Brien (2009) article brings to light the benefits for students of being outdoors in an education setting. O'Brien's focus is that of a Forest School approach, although the benefits are able to be translated to a traditional school setting that utilizes the outdoor environment. Within the contents of this article, O'Brien makes many references to the *Learning Outside the Classroom Manifesto* (2006), which is a government of the United Kingdom funded document that supports the use of the outdoor environment within education. The *Learning Outside the Classroom Manifesto* (2006) uses the National Foundation of Education Research as its primary source of research. One of the most important statements within this document, as well as being cited within the O'Brien (2009) article is that learning outdoors can have a range of positive impacts including cognitive, interpersonal and social as well as physical and behavioural impacts (p.46). Learning experiences in an outdoor environment are much different than those experiences within the walls of a classroom (O'Brien, 2009, p.46). Although this article is based on government documents from the United Kingdom, the benefits of outdoor education are relevant worldwide.

This article can be considered a reliable source of documentation and research because of its government-financed research as well as the publication being within a reputable education journal. The O'Brien (2009) article also helps to provide a rationale to support the need for more practical resources for educators to use to implement utilizing the outdoor environment as a classroom.

Peterson, S., Forsyth, D., & McIntyre, J. (2015). Balancing play-based learning with curricular mandates: Considering the views of northern Canadian teachers and early childhood educators. *Canadian Children, 40*(3), 40-47. doi:10.18357/jcs.v40i3.15168

This document is of particular interest because it connects play-based learning from a Canadian perspective. The authors reference the use of "promoting high quality, age-appropriate, play-based learning experiences" which is a mandated policy within four provinces within Canada (Peterson, Forsyth, & McIntyre, 2015, p. 40). The four provinces within Canada that include play-based learning experiences within their mandated policies are Alberta, Saskatchewan, Manitoba, and Ontario. These curriculum documents, position play as an integral part of the learning landscape (Peterson, et al., 2015, p. 40). However, once the students reach grade one, there is no mention of play within the provincially produced documents (Peterson, et al., 2015, p. 40).

Within the document, the authors reference to a study completed where several teachers were interviewed based on their perceptions of play along with barriers they face. There is significant literature referenced within the article to both support and challenge the use of play-based learning experiences within the classroom. The general consensus of the interview participants was that play should be a part of the kindergarten and grade one curriculum (Peterson, et al., 2015, p. 46). The statements and research made against the notion of play-based learning are helpful to ensure the Practical Resource Guide will meet and exceed the needs of educators.

Quibell, T., Charlton, J., & Law, J., (2017). Wilderness schooling: A controlled trial of the impact of an outdoor education programme on attainment outcomes in primary pupils. *British Educational Research Journal, 43*(3), 572-597. doi:10.1002/berj.3273

Within the contents of this article, Quibell, Charlton and Law (2017) analyze a research study completed to measure the academic outcomes of students after a trial period of wilderness schooling compared to conventional schooling. The students, aged eight to eleven years old, participated in a six-week study to test the research question of "does wilderness schooling improve educational attainment, compared to conventional schooling?" (Quibell, et al., 2017, p. 576). The study included lessons from a variety of subject areas including mathematics, science and language arts. There were notable improvements in the performance of the intervention group compared with that of the control group, specifically, "of particular interest is the uniformity of the attainment gains: in each curriculum area, the data shows children in the intervention group learning at a faster rate than the controls, demonstrated by the greater increments of scores over

time" (Quibell, et al., 2017, p. 583). The authors predicted that the success of the wilderness schooling may be attributed to the fact that when children are in the outdoors for learning experiences, it allows for increased engagement of the senses, by engaging sight, sound, smell and touch (Quibell, et al., 2017, p. 585). Having increased engagement of the senses may allow for more attentive, and richer, learning (Quibell, et al., 2017, p.585).

Within the introductory statements of this research study, Quibell et al (2017) make many observations about the potential for success, both personally and academically for students who are given learning experiences in the outdoors. These observations align with many of the resources within this annotated bibliography. The common themes assisted in supporting the justification for creating a practical resource portfolio.

Showalter, D. A. (2013). Place-based mathematics education: a conflated pedagogy? ***Journal of Research in Rural Education, 28*****(6), 1-13.**

The Showalter (2013) article takes an opposing approach to place-based mathematics pedagogies to the other articles reviewed for this Annotated Bibliography. Place-based mathematics is slightly different than outdoor play-based learning experiences. Place-based learning focuses on students connecting to a particular place and how that place informs their learning. Outdoor-based learning may take place in a consistently visited space, but it is not a requirement. Place-based and outdoor-based learning have different goals, however do share some similarities, for example, students noticing and measuring changes in the environment they frequently visit on their mathematical journeys. Showalter (2013) argues that although the place-based pedagogy is solid in theory, there are some flaws. Flaws that Showalter (2013) focuses on is that of higher leveled mathematic courses, for instance, algebra. The author report that in a study that participants were unable to make connections to their theory foundational knowledge learned in the classroom and place-based mathematical instructional times. Showalter (2013) states that it is a difficult challenge for educators to engage in instructional activities that maintain depth and authenticity at higher leveled mathematical courses. The challenge that educators face was attributed, by Showalter to the lack of practical

resources and exemplars for creating place-based mathematics lessons (Showalter, 2013, p. 10).

Although Showalter (2013) is skeptical of place-based mathematical instruction pedagogy, the benefits of the practice are highlighted in the article. “Place-based mathematical instruction has been attributed to forging classroom and community relationships, motivating students with lessons that are relevant, and engaging students with mathematical ways of perceiving their immediate surroundings” (Showalter, 2013, p. 3). Showalter (2013) also references a study that resulted in a more positive attitude towards math and higher standardized testing scores among grade four students who participated in place-based mathematics instruction.

Along with the Bonner (2014) and Barker (2014) articles, this publication does not provide direct support for the Portfolio Package. This article does however hold some significant encouragement for the practice of place-based mathematics and for the need for more practical resources.

Stegelin, D. (2005). Making the case for play policy: Research-based reasons to support play- based environments. *Young Children,* (2), 76.

The Stegelin (2005) text provides supporting evidence for the information provided by the Isenburb and Quisenbery (2002) article. These articles defend the use of play in education settings through documented research. Of particular interest within this article is the research done on brain growth and stimulation that occurs while students are at play. Stegelin (2005) reports that “Cognitive development is optimized through active, exploratory play, as evidenced through brain scans and research that document that active, stimulating play on a regular basis promotes optimal brain development in young children” (p. 16).

Stegelin (2005) states that the goal of this article is to provide educators with the means to defend the use of play-policy within their pedagogies. Although this article has no mention of benefits relating to mathematical understandings as a result of play, it does lend itself well to the development of the Practical Resource Guide.

Tucker, K. (2014). *Mathematics through play in the early years* (3rd ed.). London: SAGE.

This text offers a balanced blend between the theory of play-based pedagogy and practical tools for educators. Within each chapter Tucker (2014) offers several practical

tips for encouraging learning while the students are at play. For instance, there is a list of open-ended questions for teachers to ask to promote mathematical thinking. Within the text there is also a definition of play, and a discussion of how play promotes childhood development as supported by Piaget's theory of childhood development.

Tucker (2014) text is not directly linked to outdoor play-based learning; however, there are several instances where the author makes reference to using the outdoor environment as a learning space to promote the pedagogy. Tucker (2014) also makes many links between play and mathematical development. The author suggests that play and math are natural partners (Tucker, 2014, p. 2). The combination of play and mathematics allows the student to gain an understanding of the cultural role of math, to have a heightened awareness that mathematics is useful, and to perceive mathematical activities to be enjoyable and purposeful (Tucker, 2014, p. 2). Tucker (2014) recognizes that children will be more creative outdoors where they have the freedom to be innovative, flexible, and adaptable and the natural environment will stimulate creative mathematical thinking (p. 24).

This book is a resource that is relevant to the task of creating a practical resource tool for educators as well as for future teaching endeavours. Tucker (2014) provides support for her practical guides and tips, using childhood development theory as well as educational research.

Culminating Themes Arising from the Works Reviewed

The research reviewed presents compelling arguments for indicating the benefits of providing outdoor play-based learning experiences. Many of the sources reviewed make mention that creating these experiences is time-consuming for educators, and that educators lack practical resources. These roadblocks inform the purpose of this portfolio document. The Practical Resource Guide is created with the intention of providing a practical number sense and numeration resource for primary levelled educators. The focus on primary levelled mathematics has been inspired by the researched documents. Throughout the research phase, many peer-reviewed sources were found that support the use of play-based mathematic experiences within early year and primary levelled curriculum. These learning experiences help to create a strong foundation for more abstract concepts in later schooling years. In addition to the supporting evidence, primary leveled educators are the target for the Practical Resource Guide because in

some documents, including the Showalter (2013) article, argue that outdoor play-based mathematical experiences in higher leveled grades do not lend itself well for student understanding and academic growth.

The goal of Practical Resource Guide is to achieve one of the central themes found in the research. This theme of educators creating experiences that allow students to use their knowledge for real-life scenarios run throughout most of the researched documents. This theme is based on a constructivist approach to education, which encourages students to develop their own understanding of the concepts presented and to make sense of the world around them. Din (2016) is one example of the authors included in this annotated bibliography that supports this pedagogy. Din (2016) writes that using outdoor math instruction in the early grades is critical because young students begin to develop an awareness that math is all around them.

With this pedagogy in mind, many researchers presented in this annotated bibliography also support the need for a balance of constructivist learning and educator-directed instruction. The balance of student and teacher-directed learning creates a healthy blend of foundational knowledge and self-exploration. Keith (2018) supports this blend of instructional approaches throughout her publication, arguing “in early mathematical awareness, children need time to explore the environment, try out and explore what they can do with different materials and reflect on what has worked for them on their own through mathematical play (Keith, 2018, p. 72). It will be through the developed play-based experiences that students will be able to have the time needed to explore their knowledge, test their skills and make real-life applications through problem solving.

References

Boaler, J. (2015). *The elephant in the classroom: Helping children learn and love maths.* London, UK: Souvenir Press.

Council for Learning Outside the Classroom. (2016). *Learning outside the classroom manifesto.* Nottingham, UK: Department for Education and Skills

Chapter Three: Practical Resource Guide

Section One: Number Lines

Introduction to the Experience:

Number lines are an interactive resource teachers can use in the outdoors for students to develop early counting skills and provides the experiential learning necessary for later visualization of abstract number concepts (Keith, 2018, p. 92). Students can use number lines to identify benchmark numbers, practice number writing and recognition, as well as practice counting on and counting back. Incorporating number lines into mathematical experiences is a key strategy within the components of developing numerical proficiency: magnitude, comparisons, strategic counting, retrieval of basic arithmetic facts, work problems and numerical recognition (Ferguson, Mink, & Wetzel, 2012, p. 90). Using number lines through movement and exploration will lead to a higher sense of numerical fluency. "Developing fluency with basic facts is not developmental process…flashcards and timed tests are not the best way to develop fluency" (Van De Walle, Bay-Williams, & Karp, 2014, p. 195).). The number line learning experiences described within this section are in addition to the rote methods of developing fluency

The purposes of the number line activities are to be a permanent or frequently co-created feature of the outdoor learning space that can be referred to during mathematical experiences.

In rural and urban settings, the potential for number lines is abundant!

Enduring Understanding	**Extensions**
• Numbers relate through comparisons of quantities, including greater-than, less-than, and equal-to relationships (Van De Walle, et al., 2014, p. 142)	• Using number lines to develop part-part-whole relationships
Suggested Materials	**Key Math Language**
• Chalk • Sidewalk Paint* • Clothes Pins • Bristol Board • Construction Paper • Markers *See page 29	• Number Line • Counting on • Counting back • More-than • Less-than • Equal-to • Subitizing* *See page 29

Experience Outline

Sidewalks as Number Lines

- Using chalk or sidewalk paint, paint the school's sidewalk to create a number line. While the students are at play, teachers may create the number line or prompt the students to do so.
    - This number line may lead to questions about counting how many pieces of sidewalk there are around the school, which may also extend into measurement activities.
        - Measurement activity extensions include using non-standard units to determine the perimeter of the school. "Our school is 250 sidewalk squares around". Building on this activity, once the students determine the length of a sidewalk square they can problem solve the perimeter around the school using units of measurement.
    - When creating the number line be sure to have equal space between each number. This practice will help to reinforce to students that each number represents 'one unit' and that same unit is repeated over and over to form a number line (Van De Walle, et al., 2014, p. 175).

Daily Physical Activity

- Using a set of large dice, each student has a turn to roll. The number that is rolled indicates where the students must go on the number line. For instance, a student skips to the number three on the number line, when a three is rolled on the dice
    - Movement actions* can be created on small cards to be drawn from a container
    - This activity encourages movement, but also allows students to practice subitizing and quick addition (if using a set of dice).
- If sidewalks are not easily accessible or pose safety concerns, teachers may opt to use a fence line.
    - Using laminated card stock and clothespins, attach the number line to a fence line. Ensure each card is equal distance apart from each other.

Group Management Tip

- Play this game with a small number of students within a centre rotation system. This will cut down on student wait times and potential for disruptive behaviours.
- While students wait, they may create individual tallies using a clipboard to record the number that is rolled. Ask, "what number was rolled the most?" or "what number was rolled the least?'.

Number Lines on the Go!

- Using medium sized stones or wood cookies, write a number on each object to create a number line set. This can be added to a loose parts section in an outdoor classroom.

Staircase Number Lines

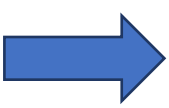
- When students are gathering natural materials while at play or guided exploration, a pictorial representation of a number line can be created.
- The materials that are gathered can be added to a previously created number line (on a sidewalk, or fence line) or, the educator may choose to prompt the students to notice what is happening as they are grouping their collected objects.
    - "I'm seeing one acorn, two pinecones, three pieces of litter. What does this remind you of?"
- Adding natural materials to a number line will help students to make the connection between the visual representation of a number and the amount.
- Creating staircase number lines will lend itself nicely to graphing and data collection.
    - "On our journey, we were able to find; 3 round rocks, 6 acorns and 2 pine cones".

*See page 30

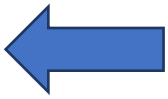
Assessment Opportunities:

With having access to number lines, students have the choice to use the resource in their mathematical exploration. During this exploration, teachers are encouraged to gather insightful observations of what the students are doing and saying. How are the students interacting with the numbers? For instance when using numbers written on wooden cookies, are they arranging them in numerical order? This information can supplement other data or used in lesson planning, providing feedback, and generating conversation.

Observations can be collected through short video clips, pictures, or anecdotal notes. Preprinted cards* for observations can be attached to a clipboard for quick access and easy note taking.



Create the preprinted cards alphabetically for the convenience of finding student names



What Mathematics are Students Learning?

When using number lines as a reference tool during mathematical experiences, students are able to have a visual representation of the meaning attached to numbers and counting. Once students begin to develop the foundational understanding of the meaning attached to numbers and counting, they will understand the sequential order of counting. For example, six always comes after seven. Understanding sequential order extends to counting on, counting back and skip counting skills. Number lines also provide a visual representation of benchmark numbers. The students are able to discover that five is halfway to ten, which then also has the potential to extend into fractional thinking. Number lines are a gateway for students to develop the meaning of zero and its relationship with other numbers, in particular when exploring ‘how many’.

For the purposes of the suggested learning experiences, it is recommended to start the number line at zero. “A number line measures distances from zero the same way a ruler does” (Van de Walle, et al., 2014, p. 175). If educators are not including the use of a number line through an emphasis on the unit, students may focus on the numeral rather than the spaces (Van de Walle, et al., 2014, 175). This misunderstanding will become apparent when solutions are constantly one number off. The ending point of the number line will be determined by the academic level of the students; the goal is not to overwhelm the students, but to also gently scaffold their learning. With this in mind, creating a number line that moves beyond ten will help students develop their understanding the sequential ordering of numbers.

***Sidewalk Paint Recipe** Ingredients • 1 cup corn starch • 1 cup water • Food colouring	Instructions • Mix the corn starch and water together until the corn starch is dissolved • Add food colouring until desired colour is achieved • The paint will go on 'watery' but will become more vibrant as it dries

***Subitizing**: The understanding of subitizing is the ability to be able to 'just know' the number of dots. For example, knowing that there are three dots rather than having to count. "Subitizing is a fundamental skill in the development of children's understanding of number…subitizing can be a complex skill that needs to be developed and practiced through experiences with patterned sets" (Van de Walle, Bay-Williams, & Karp, 2014,p. 144).

Anecdotal Records Example	
Tennyson	Colby
Madeleine	Skielor

Number Line Hop Movements		
Skip	**Tip Toe**	**Bear Crawl**
Hop like a Bunny	**Monster Steps**	**Crab Walk**
Leap like a Frog	**Slither like a Snake**	**Side Steps**
Gallop	**Run**	**Walk**

Section Two: Everything Counts

Introduction to the Experience:

With some creativity and purposeful questioning, everything can be counted, and tracked while students are at play. Using the natural world as the classroom inspires students to make their own connections between curriculum being taught and the world outside of the classroom walls. "The outdoor environment has unique characteristics and is richly resourced in materials that can be used as tools for learning-it is multi-sensory, enabling learning to take place through engagement of the senses" (Law, 2017, p. 575). Incorporating counting into play encourages students to practice their one-to-one counting, the sequential order of counting, and understanding the amount of a number. The learning experiences are created on the foundation of play within the multi-sensory outdoor environment to practice and develop counting skills.

> We need to consider which resources in the outdoor environment promote this stage of counting (one-to-one counting) by moving rocks one at a time, stacking blocks to make a tower, moving balls along a string on the wall to see how many there are. Real contexts for counting that arise from the children's natural curiosity and desire to count will impact greatly on their attitudes to seeing a purpose of counting (Keith, 2018, p. 51).

Enduring Understanding	**Extensions**
• Counting tells how many things are in a set. When counting a set of objects, the last word in the counting sequence names the quantity for that set (cardinality) (Van De Walle, et al., 2014, p. 142)	• Part-part-whole relationships • Estimation • Measurement
Suggested Materials	**Key Math Language**

• Natural Materials
  ○ Acorns
  ○ Pine Cones
  ○ Leaves
  ○ Dandy Lions
  ○ Stones
  ○ Sticks
  ○ Trees
  ○ Birds
  ○ Squirrels
• Urban Materials
  ○ Vehicles
  ○ Cyclists
• Mini Clip Boards*
• Pencils
*See page 35
	• Cardinality*
	• Abstraction*
	• The Order of Irrelevance*
	• Counting on
	• Counting back
	• One-to-one
	• Sequence
	
	*See page 35

Experience Outline

Tallying in Urban Settings

- Take a trip to the school parking lot or a nearby street. Use mini clipboards to create a tally of how many cars are in the parking lot or how many cars go by in a certain amount of time.
    - How many cars are there if one person leaves?
- An extension of this activity can be to sort vehicles into groups.
    - Cars, trucks, or by colour.
    - What type of vehicle went by us the most?
    - Invite the students to create their own classification system for the vehicles
    - A further extension to this can be linked to probability.
        - Based on our findings, what colour of car do you think is most likely to drive by next?
- Sticks also are a great natural material for creating tally marks.
    - Rather than using paper and a pencil, lay sticks vertically to create the tally marks. Or, if in an area with packed sand, use sticks as the 'pencil' and the 'sand' as the paper.

Tallying in Rural Settings

- Find a quiet spot on the schoolyard and tally how many creatures you see.
- This is also a great way to introduce seasonal changes.
    - In the spring are you seeing more animals being active in the outdoors? What animals are you seeing now that you did not see in the winter?

Collect Them All

- This experience is an adaptation of Robertson's (2017) Find a Number activity.
- After students have been collecting natural materials, gather the students in a circle and put their collections in front of them.
- Prompt the students to count everything they have found. Is there another way to count them?
    - Counting by 2s, 5s.
    - Making arrays with the materials (2 groups of 4).
- After each student is comfortable with determining how many objects they have collected start calling out actions.
    - Sit down if you have fewer than ten objects.
    - Switch places with someone if they have the same amount as you.
    - Hop on one leg if you have different kinds of objects.
    - Clap your hands if you have an even/odd amount.
    - Find someone with the same object as you. How many do you have in total?

Group Management Tip: Before starting the experience, discuss with the students that they will end up back with their original collection once the game is over. Often students are protective over their discoveries and may be apprehensive to leave their space. With a quick discussion this can be avoided.

Creating Connections

This experience is a tool that educators can use in the development of addition and subtraction skills.

- Create several part-part-whole connection circles* in snow with food colouring, or on pavement using chalk.
- Students may choose to make their own small connection circles to experiment with natural materials. Alternatively, rather than using natural materials as the manipulative students may use their bodies.
- These connection circles can become a staple within the outdoor play environment when students are challenged with counting 'how many in total'.

*See page 36

Assessment Opportunities:

After guided experiences with counting in the natural world, educators may begin to notice their students counting everything. Learners will be counting rocks they have found, pine cones will be traded for acorns, and negotiations between students will be made on the number of sticks that will be needed to complete a structure. Within these moments, educators will have ample opportunity for anecdotal note taking, even beyond the mathematical and language curricula. How are students working together? Are students demonstrating self-regulation, and problem-solving behaviours?

Using natural materials as the counting manipulative expands the horizons for educators completing the rote assessment of student knowledge. In the natural environment, the students may perform at a higher achievement level than they might within the classroom walls. Students are able to learn best when they are happy, secure, and can learn through play (Keith, 2018, p. 4). In the outdoors, students may feel more at ease during assessments, and therefore may perform better. Learners may also feel at ease during assessments if the manipulatives they are using, are a part of the world they are in during play.

Counting natural manipulatives, or manipulatives that can be found in the outdoors is a strategy that educators can use to assess the level which the student is performing, within the counting trajectory model.

Learning Trajectory for Counting

Level of Thinking	Characteristics
Precounter	No verbal counting skills demonstrated. Does not associate a number word with a quantity.
Reciter	Verbally counts using number words but not always in the right order. Sometimes says more numbers than they have objects to count; skips objects or repeats numbers.
Corresponder	Makes one-to-one correspondence with numbers and objects. When asked 'how many?' after counting, may have to recount.
Counter	Accurately counts objects in an organized manner (i.e., in a line) and can answer 'how many?'. May be able to write the matching numeral.
Producer	Can count objects to a certain number. If asked to show an

	amount, the student can show you.
Counter and Producer	Combines the previous two levels. Can count objects, tell how many are in a group, remember which objects are counted and which are not, and respond to random arrangements. Begins to separate tens and ones.
Counter Backwards	Can count backwards by removing objects one by one or just verbally.
Counter from Any Number	Can count up starting from numbers other than one. Also, is able to immediately state the number before and after a given number.
Skip Counter	Can skip count with an understanding of grouping a certain number-tens, fives, twos, etc.

(Van de Walle, et al., 2014, p. 146)

What Mathematics are Students Learning?

During counting experiences in the outdoors, students are developing their foundational knowledge of number sense. This includes, but is not limited to, number recognition and how amounts are related to a written number. "Objects found in the outdoors can be a starting point for a collection that can teach numerous concepts to children. The objects inform children that math exists at home, in the school hallways, and on the way to and from the school" (Ashbrook, 2017, p.118). Using manipulatives that are found in the outdoor environment will allow for a deeper connection to their learning and therefore a deeper understanding of the concepts being learned. "The need to incorporate play into maths and the development of more concrete experiences for young children, especially in the developing counting skills and a deeper understanding by practitioners is the key skill of number sense" (Keith, 2018, p. 4)

When the students are able to explore an environment, choose and find their materials, their interest level will increase. The students become an active part in their learning. Experiences with loose parts allow children to be in control, deepen their critical thinking skills and generate new and creative ideas in solving problems (Keith, 2018, p. 104). The experiences generated by using the outdoor world as the learning space provides students opportunities to practice skills beyond what is set in the curriculum. They are self-regulating, problem solving and demonstrating grit. These are valuable attributes which are highlighted within the Problem - Solving and Innovating, Self-Regulation and Well-Being, and Belonging and Contributing frames of the 2016 Ontario Kindergarten Curriculum.

Naturally, young students will collect their discoveries in the outdoors. Often students will come in from recess with stones in their pockets or insist on keeping a special leaf. This is a prime opportunity for educators to prompt the students to count, classify and sort their findings.
"How many stones did you collect?"
"Is there a way for us to sort them?"
"What do you notice about these two leaves?"

We can use children's interest in creating collections to engage them in learning logico-mathematical knowledge through:

1. Classification (mentally putting together things that are alike and separating those that are different)
2. Seriation (Mentally ordering things according to their differences)
3. Number (or numerical relationships)
4. Spatial relationships (mentally ordering things according to their order in space)
5. Temporal Relationships (mentally ordering things according to their order in time)

(Ashbrook, 2017, p. 118)

Mini Clipboard Creation*

Materials

- Thick cardboard cut into desired sized rectangles
- Cloth fabric cut into the same sized rectangles as the cardboard
- Pipe cleaners
- Paper, cut to the same size or smaller than the cardboard rectangles
- Hole Punch
- Pastels or Markers

Instructions

- Decorate the cloth fabric using the pastels or markers. Ensure students put their name on this fabric. This is their special clipboard for recording.
- Using the hole punch, punch out two holes at the top of the paper.
- Align the paper to the top of the cardboard rectangle and punch out two holes.
- Repeat this process with the decorated cloth fabric
- Align the fabric, paper and cardboard and use pipe cleaners to attach

To add additional paper, undo the pipe cleaner attachments

Cardinality*

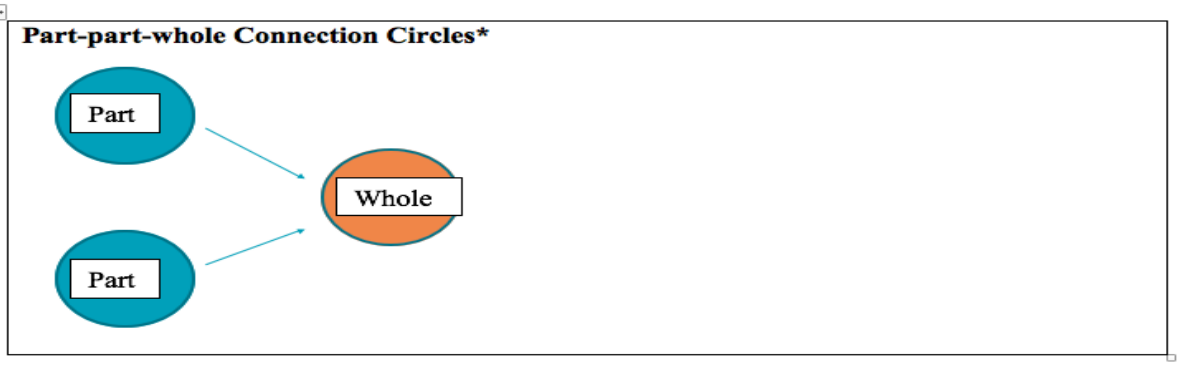
- Counting tells how many things are in a set. When counting a set of objects, the last word in the counting sequence names the quantity for that set (Van De Walle, et al., 2014, p. 142)

Abstraction *

- Involves learners in moving from counting objects that are the same (5 acorns) to an understanding that if we choose, 2 acorns and 3 pine cones, there are still 5 objects (Keith, 2018, p. 52).

The Order of Irrelevance*

- A concept developed in learners, that it does not matter where you being counting, the overall final count stays the same (Keith, 2018, p. 52).


Part-part-whole Connection Circles*
Part
Part
Whole

Section Three: The Community as the Manipulative

Introduction to the Experience:

Bringing students out of the classroom and into their communities, the learners are able to experience the role that mathematics has beyond their worksheet. While exploring the community, both in natural and urban settings, the students have ample opportunity to experiment with concepts taught. Young children have the natural urge to collect items they find. These objects can be a starting point for a collection that can reinforce numerous concepts (Ashbrook, 2017, p.188). Allowing students to explore with materials they find, gives them a sense of agency and choice with their learning. Researchers have found that outdoor instruction helps to improve content relevance for students, in addition to increasing student interest and academic achievement (Din, 2016, p. 16).

The community is a treasure chest full of mathematics manipulatives and learning opportunities, and the educator has the key.

> Math is full of creativity and about life. In thinking of maths only in terms of a worksheet or tasks to be completed, we risk gaining a full understanding of what children already know about the world and lose the possibilities to make the 'invisible visible' through quality interactions and appreciating this part of childhood as a time in its own right (Keith, 2008, p. 5).

Enduring Understanding	**Extensions**
• Number relationships provide the foundation for strategies that help students remember basic facts (Van De Walle, et al., 2014, p. 194)	• Measurement • Creating categories • Patterning • Urban planning project-based learning
Suggested Materials	**Key Math Language**
• Natural Materials o Acorns o Pine Cones o Leaves o Stones o Sticks o Trees and Plants o Wildlife • Urban Materials o Vehicles o Litter o Cyclists o Waste Disposal Stations o Bird Feeders o Bird Seed o Pencils o Mini Clipboards (introduced in experience 1)	• Fluency • Counting • Part-Part-Whole • Collecting • Cardinality • Counting Strategies • Basic Fact Phases* *See page 40

Experience Outline

Math in the Park

- Take a trip to a local park to discover all the things that can be collected, sorted and counted.
    - As students gather and notice natural or synthetic items within their play, use prompting language to invite them to count, group and keep track of what they find.
        - "Is there another way to sort your collection?"
        - "How many do you have?" "How many more would you need to have 10?"
    - Use prompting language while students are noticing the world around to help in the development of understanding part-part-whole relationships.
        - "This afternoon as a class, we saw 4 chipmunks, 3 birds and 1 squirrel. How many animals did we see altogether?"
    - Encourage students to create categories in the items they collect and prompt the students to work together as a team.
        - "How many acorns do we have all together?" "What would happen if a squirrel came and ate 3 of our acorns?"
    - As students start to develop their number sense foundations, natural materials can also be used to create arrays.
        - "How many groups of 3 can be made from your 12 pine cones?"
- Include taking a trip to a local park as part of the weekly routine. Consider joining with an older grade to assist in walking to the park and exploring.
    - As the students visit the park more frequently, create an environmental assessment of the park with the students.
        - "How much litter is there on the ground?"
        - "Does the amount of litter change as the seasons change?"
        - "What do you notice about the waste disposal stations?" (Is there enough; are they often overflowing?)
    - Use the information gathered over an extended period of time to create an official document to present to the town.
        - "Our class noticed that on Mondays, the waste disposal stations are often overflowing and there is an increase of litter on the ground."

Fill the Bird Feeder

- An adaptation to Van De Walle's (2016) Fill The Tower activity, the students take turns rolling dice to indicate how many scoops of birdseed they can add to the bird feeder.
    - Before starting this experience, ask the students to estimate how many scoops they think it will take to fill the feeder.
    - This experience may also lead the students to determine how many seeds are in each scoop, or in total! Prompt the students to experiment with different strategies to solve this question. In older primary grades, this will lead nicely to creating arrays.
        - Consider the use of language within this extension. "There is *about* 100 seeds in each scoop".

- Once the bird feeder is full, hang it up and wait! Encourage the students to count the visitors to the feeder. Prompt the students to create categories for who visits by species of bird or by size.
- What other creatures are visiting the bird feeder? Use the mini clipboards (described in learning experience two) as a tool for creating a tally system.
- Referencing back to this activity will lend itself well to measurement experiences.
- For more advanced learners, use a measurement tool as the 'scooper'.
    - "What is the volume of the bird feeder?"

Materials Tip
Use a small scoop for pouring the birdseed into the bird feeder. This will ensure that students each have a turn to add some birdseed before the feeder is full. Also, consider having a funnel on hand to reduce mess and wasted birdseed.

Assessment Opportunities:

While on trips to the park, educators may choose to use this instructional time for their 'assessment as' assessment piece. The educator may assess to understand where the students are lacking in their knowledge, where their interests are and how they are flourishing. This information will help to guide indoor instructional time. Research shows that a mix of indoor and outdoor instruction leads to improved achievement (Barker, 2015 p. 1). Having this mix of instructional spaces may reduce monotony in school tasks, which allows for more excitement and greater interest in the tasks.

Within the experiences outlined in the current section, there are several opportunities for educators to gather information from students as they practice their mathematical fluency. Are the students able to communicate their reasoning for grouping certain materials together? Is a student able to make connections and a variety of representations of amounts? Developing early mathematical awareness takes time and is a complex process with an interrelated set of skills and conceptual understanding which need to be explored, revisited, and applied in different contexts (Keith, 2018, p. 49). The intricacy of developing mathematical awareness makes the outdoor environment an ideal setting for new experiences and making connections with those developed in the indoor setting and vice versa (Keith, 2018, p. 49). Students who are struggling with concepts taught in the traditional manner, may flourish once the learning setting has changed, or when they find their own learning materials. During small group instructional times, teachers may be included to use the Van De Walle (2014) Strategies for Assessing Basic Fact Fluency table to determine the aspects of fluency students are demonstrating.

Effective Strategies for Assessing Basic Fact Fluency	
Aspects of Fluency	Observation
Appropriate strategy selection	As they play a game, are they using a strategy that makes sense for that fact?
Flexibility	Demonstrating flexibility for selecting a strategy for solving equations. Do they notice

	that 8 + 3 is also 3 + 8?
Efficiency	How long does it take to select a strategy? Are they quick to use doubles? Does efficiency vary with certain facts?
Accuracy	Which facts are they consistently getting correct?

(Van Der Walle, et al., 2014, p. 198)

What Mathematics are Students Learning?

When students are out of the classroom and interacting with their community in a mathematical way, they make the connection that math exists beyond the formal instruction in the classroom. After making this link, students may have a greater investment in their school tasks and thus have an increased opportunity for learning. In early mathematical awareness, children need time to explore the environment, try out and explore what they can do with different materials and reflect on what has worked for them in their own way (Keith, 2018, p. 72).

While on an exploration of the community, students engage in a variety of tasks using the natural and urban setting to;

- Collect and count a variety of objects to represent different quantities in order to develop students' number sense.
- Gather objects of natural groupings, such as flowers with five petals, or three-lobed leaves, to work on skip counting and counting by groups or creating arrays.
- Estimate lengths of both natural objects (branches) and structures to begin developing an understanding of measurement and estimation (Din, 2016, p.17).

The discussions facilitated by the teacher during these activities are aimed at supporting not only mathematical understanding of concepts, but also their perception of the role math plays in the world around them (Din, 2016, p. 17). During class discussions, teachers may be able to assess the students using the Van De Walle (2014) Basic Fact Learning Phases to determine the level the students are demonstrating an understanding of basic mathematics facts.

Basic Facts: Learning Phases

Phase One: Counting Strategies

- Using object counting (blocks or fingers) or verbal counting to determine the answer.

Phase Two: Reasoning Strategies

- Using known information to logically determine an unknown combination.

Phase Three: Mastery

- Producing answers efficiently.

(Van De Walle, et al., 2014, p. 195)

Section Four: Establishing Routines

Introduction to the Experience:

The experiences included within this section are intended to be included in daily or weekly classroom routines. The games can be used for students to play when they finish a task, or activities to include during calendar and meeting times throughout the day. To develop mathematically literate citizens, students require experiences that help them understand and relate to math concepts in various contexts (Din, 2016, p. 16). When students encounter mathematics throughout their day beyond the designated math block, the awareness that math exists everywhere in the world is further solidified.

The outdoor play space a schoolyard provides is an excellent resource to include within daily class routines. Using outdoor math instruction in the early grades is critical because young students can begin developing an awareness that math is all around them, making mathematical connections to real life settings and building an appreciation for the role math plays in their world (Din, 2016, p.16). Creating routines and experiences alongside students also gives them ownership and leadership within their learning.

> A schoolyard is a convenient setting for many math activities and is especially suited for concept application and problem-solving. Number sense, patterns, and relationships, measurement, estimation, geometry, statistics and probability-mathematics is, at its root, a way of describing the world and its patterns (Benanson, & Killion, 2001, p.31)

Enduring Understanding	**Extensions**
• An estimate refers to a number that is a suitable approximation for an exact number given in the particular context. (Van De Walle, et al., 2014, p. 270) • Skills needed in the 2s1st-century workplace are less about being able to compute and more about being able to design solution strategies. (Van De Walle, et al., 2014, p.33)	• Measurement • Part-Part-Whole Relationships • Fractions • Decimals
Suggested Materials	**Key Math Language**
• A large mason jar • Pebbles • Birdseed • Pine cones • Acorns • Leaves • Small sticks • A tree with low branches • Laminated cardstock* • Yarn • Scissors • Dry erase markers & erasers	• Estimation* • Problem Solving • Strategy • Groupings • Routines *See page 44

Experience Outline

Estimation Station

- Estimation can be a difficult skill to develop. As students begin to develop their number sense, they move away from haphazardly guessing a number to using estimation strategies to make their best guess. For example, "What does ten of something look like? What about 100?"
- Include an 'Estimation Station' in the outdoor provocations to invite the students to create their best guess to solve 'how many'.
    - Include pencils and small pieces of paper for students to write their name and their guess. For more advanced learners, you may wish to ask them to include their reasoning for their estimation.
    - Once all students have had an opportunity to visit the Estimation Station, have a sharing circle for the group to discuss some of their strategies.
    - As a group use a chosen strategy to count the amount.
- Students also have a fascination with large numbers, and using an estimation station helps to develop the concept of what does a thousand or a million of something really look like.
    - Literature Link: A Million Dots, by Andrew Clements.

Materials Tip:

- The jar does not need to be full! Start small to build a foundation in the students' reasoning.
- "Thinking back to yesterday, we know what 10 acorns look like. Does this look like more than or less than 10?"

The Game of Nim

- This experience is inspired by the Robertson (2017) text.
    - In partners, students collect a total of 20 natural materials. The materials can be all of the same type or a varied collection to make 20.
    - Taking turns, students choose to take one, two, or three counters from their collection of materials.
    - The player who picks up the last counter loses the game.
- Increasing the difficulty.
    - An alternative to this game is to reverse the process.
    - Each player starts with 10 counters, with 1 in the middle. Taking turns, each player must add 1, 2, or 3 at a time to try to make the designated total.
    - The goal is to be the player who adds the correct amount of counters to reach the designated number (such as 15 total counters).

Number Tree

- Prepare* for this routine by pre-placing numbers written on laminated cardstock on a tree.
    - If trees are limited in the outdoor space, a fence line will work well too. Alternatively, create a figure of a tree as a class project.
    - Intentionally select the numbers being placed on the tree by theme. Potential themes may include;
        - Odd/even numbers
        - Prime numbers

*See page 44

        - The same number
        - Numbers that are all greater/less than ten
    - During a gathering circle or during play, prompt the students to notice the tree.
        - "What do you notice about the numbers?"
- A number tree is a fun alternative to an advent calendar. Use the numbers to count down to a special day!
- The goal of the routine is to reinforce number sense among the students. For some students, it may be number recognition and for others, it could be making connections and patterns with numbers.

Assessment Opportunities

When educators include mathematics within their daily routines, they are able to determine what the students are retaining and the connections that they are making on their own. Beyond the mathematics that can be assessed, the routines and games that were provided within this experience also enable educators to assess how students communicate and collaborate with one another. Assessment may also be taken to determine how students are able to follow routines and instructions independently.

Providing estimation activities is a method for educators to assess how students are developing their computation skills. Students with solid computation skills, tend to be more confident in their estimation tasks (Van De Walle, et al., 2014, p. 270). During these routine activities, educators are able to see which students are struggling with the concepts being discussed. For example, if a student is reluctant to share their estimation strategy, they may be feeling uncomfortable with their general number sense skills.

What Mathematics are the Students Learning?

The learning experiences provided in this section offer students the opportunity to practice their number sense skills but also practice working alongside their classroom peers. There is research to show that discovery activities and challenging problem-solving activities that require collaboration and communication between students are more powerful in creating deeper learning than passive, consumptive activities (Barker, 2015, p.2). The students are also put into situations where they apply previously learned concepts to tasks beyond their designated math block. Children acquire conceptual knowledge by taking pieces of information they have already gained from experience and connect them with things they have learned into existing mental structures (Ferguson, Mink, & Wetzel, 2012 p. 90). These connections can be applied during the Number Tree activity, for example. Students are applying what they know about numbers to solve the pattern that has been made on the tree. Routines within the natural area further reinforce that mathematical application are all around us. A natural area and the objects and phenomena within it can be estimated, counted, and measured and the data collected can be charted, tabled, averaged, graphed, and manipulated in many ways (Benanson, & Killion, 2001, p. 31).

Number Tree Preparations*

- Cut cardstock into desired-sized squares. There will need to be enough for each student in the class and a few extras.
- Laminate each square and remove excess plastic.
    - These squares are intended to be used repeatedly as the routine develops.
    - There is the option here to also use subitizing dots on the reverse side of the written numeral. Including the subitizing dots will help in the reinforcement associating an amount with written numbers.
- Use a hole punch to create a single hole at the top of each cardstock square. Give enough allowance on the cardstock to prevent easy tearing.
- Cut the yarn into long enough strands for easy removal. Thread the cardstock numbers into each yarn strand and tie off.
- Use dry erase markers to write each number.
    - Pom-poms or socks make great erasers.
    - Hand sanitizer is an effective way to remove dried marker.

Estimation*

Estimation refers to three different ideas:

- Measurement estimation: Determining an approximate measure without making an exact measurement.
- Quantity estimation: Approximating the number of items in a collection.
- Computational estimation: Determining the number that is an approximation of a computation that we cannot or do not need to determine precisely.

Van De Walle, et al., 2014, p.270

Section Five: Outdoor Play

Introduction to the Experience

The games included in this section add an element of mathematical experience in a dynamic way to approach daily physical activity. When students are in need of a 'brain break' throughout their day, movement through outdoor play is a good choice. Incorporating a little math within these times allow students to work out their brains as well as their bodies.

These games may also be used as a part of a minds-on activity. Games motivate children to learn arithmetic (Ashbrook, 2017, p.118). With using low-pressure games, students are able to relax and feel safe to experiment with numbers, and thus be more open to learning. Confidence grows when students can build on understanding, make links, learn more from each other and play mathematically in a more cooperative way (Keith, 2018, p.49). Playing games with numbers also show students that mathematics is not scary and can be fun!

> Mathematical conversations occur naturally among children during play outdoors. We need to tune in to the children's play and see the opportunities for mathematical learning as we go along, and perhaps create an area that meets the children's philosophy of how they learn best (Keith, 2018, p.15).

Enduring Understanding	**Extensions**
• Math exists at home, in the school hallways, and on the way to school (Ashbrook, 2017, p.118)	• Graphing • Part-Part-Whole Relationships • Multiplication • Division • Fractions
Suggested Materials	**Key Math Language**
• Number card necklaces* • Giant Dice • Hula-Hoops • Food Colouring • Sticks • Laminated Number Hunt Playing Card* • Mini Clipboards • Dry erase markers and erasers • Leaving school property policies *See page 48	• Counting • Play • Patterns • One-to-one correspondence

Experience Outline

You and Me Makes Three

- Begin by giving each student a number card necklace*. Depending on the grade level of the students, numbers can range from 1 through to 10 or up to 20.
    - Arrange the students into a large standing circle.
    - Start the game simply by calling out a number (or roll the dice). Each student with that number needs to move (run, hop, skip, jump) to another place in the circle.
- For more advanced players, students need to create groups to equal the amount called using mathematical number sentences.
    - For example, if a five is called, a 2 and 3 could make a group. Give an opportunity for some groups to explain their thinking.
        - Groups can be made out of any number of students. The more developed the mathematical reasoning, the more thought can be put into the groupings made.

Target Practice

- Natural and synthetic materials can be used in the outdoors to create target practice games.
    - Target practice games emphasize the use of gross motor skills and concentration, but also provide opportunities for students to keep score.
        - Create targets using hula-hoops, sticks, or food colouring in the snow. Use stones, pine cones, or acorns as the item being tossed.
        - Keeping score helps students with their addition as well as cooperation skills, such as taking turns.
        - Prompt the use of different tiered scores. For example, if the object lands on the edge of the hula- hoop it is worth 5 points, but inside the hula-hoop it is 10 points.
            - Encourage the students to take the led with their scorekeeping.
            - "Can you explain how you are using the twigs to keep score?"

Going on a Number Hunt

- Before embarking on your number hunt journey, consult school policy on leaving school property. Consider if there are sidewalks for the entire walk, as well as if you need additional adults and permission forms.
- Take the students out on a number hunt! Walk around the school community to discover all the numbers that are in the world around us.
    - Discuss the places where numbers were found and why they were there.
    - Bring along the mini-clipboards as created during Section 1 for students to use as a part of a Number Hunt Playing Card*.
    - While out on the number hunt, encourage the students to check off the numbers they have found or, alternatively to keep a tally of each number.
        - "I wonder what number we will see the most?"
    - Consider extending this experience to a graphing activity. Co-create a bar graph to discover which number the class saw the most or the least.

*See page 48.

Assessment Opportunities:

The intention of these activities in this section is to provide mathematical experiences within daily physical education breaks. Therefore the idea is to enjoy these experiences alongside the students and to let the games flow. With this purpose in mind, these opportunities can be used to provide anecdotal evidence for various learning skills associated with playing games. These skills include cooperation with other students, self-regulation, leadership and contributing to a group task. Before starting these activities, take a few moments with the students to brainstorm what these skills look like to promote the skills you will be hoping to observe.

"What words might we use to show cooperation?"

"What does our body look like to show that we are in control?"

If the intent of these games are to be used as a minds on activities, consider assessing how the students are working with the numbers. Are they only interacting with numbers below 10? When counting several objects, are they confident in their one-to-one correspondence, or are they able to skip count? Use mini-conferences with the students to discuss their strategies, and take anecdotal notes, rather than using a checklist. These free-flowing casual conversations will help the student feel at ease and more likely to try something new.

> The importance of young children's learning on the need for play-based learning, exploration, building resilience, being active and engaged in the learning process, making decisions, making connections, thinking skills and creativity. All of these skills and dispositions are central to developing young children as mathematical thinkers and learners (Keith, 2018, p.4)

What Mathematics are Students Learning?

While using play as the medium to support mathematical thinking, students are not only developing their mathematical literacy, but also important social skills. Research shows that student learning is mediated by culture, language, and other socially constructed factors and students are best understood in relation to their environment, and teacher interactions with students (Bonner, 2014, p.380). Bonner's (2014) description of factors associated with student learning are social and therefore culturally significant, and have an impact on student identity development and perceived ability in mathematics. It is during outdoor play, where deep connections are made between students, and among students and teachers as well as the materials used during play.

When students are given the opportunity to play and to incorporate what they have learned throughout instructional time, they are given the license to test out their knowledge without fear of failure. Developing counting skills is the key understanding of number sense (Keith, 2018, p.4). Using experiential mathematical play is a strategy teachers can use to further strengthen foundational understanding of counting. For example, during the target practice game within this learning experience, students are able to practice one-to-one correspondence, and addition skills while keeping score. To increase the difficulty of this experience, teachers may prompt their students to practice skip counting the objects tossed.

Number Necklaces Creation*

Materials

- Yarn or Lanyards
- Cardstock
- Markers
- Scissors
- Hole Punch

Instructions

- Cut cardstock into desired squares. There will need to be enough for each student in the class, and a few extras.
- On each cardstock square, write a number based on the mathematic developmental stage. If in early primary grades a number one through to ten. As the developmental stages increase, so will the numbers that will be used.
    - There is the option here to also include subitizing dots along with the written numeral.
- Use a hole punch to create a single hole at the top of each cardstock square. Give enough allowance on the cardstock to prevent easy tearing.
- Cut the yarn into long enough strands for ease of use, thread the cardstock numbers into each yarn strand and tie off to create a necklace.

Another option is to attach the hole punched cardstock square to a lanyard.

References

Ashbrook, P. (2017). The early years: Taking math outside. *Science and Children, 54*(9), 118-119. **doi:10.2505/4/sc17_054_09_18**

Barker, J. (2015). *The fearless classroom: a practical guide to experiential learning environments.* New York: Routledge.

Benanson, C., & Killion, J. (2001). Moving math outdoors. *Green Teacher,* (64). 31.

Bonner, E. (2014). Investigating practices of highly successful mathematics teachers of traditionally underserved students. *Educational Studies in Mathematics,* (3). 377. **doi:10.1007/s10649-014-9533-7**

Clements, A & Reed. M. (2006) *A million dots.* New York: Atheneum Books for Young Readers.

Din, S. (2016), Outdoor mathematics education: using outdoor environments to deepen students' understanding of mathematical concepts. *Pathways: The Ontario Journal of Outdoor Education, 29*(1). 16-19

Ferguson, C., Mink, D., & Wetzel, B. (2012). Number sense: Strategies for helping preschool through grade 3 children develop math skills. *YC Young Children,* (3), 89.

Keith, L. (2018). *Developing young children's mathematical learning outdoors: Linking pedagogy and practice.* New York: Routledge.

O'Brien, L. (2009). Learning outdoors: The forest school approach. *Education 3-13, 37*(1), 45-60.

Robertson, J. (2017) *Messy Maths: a playful, outdoor approach for early years.* Wales, UK: Independent Thinking Press.

Van De Walle, J. A., Bay-Williams, J.M., Karp, K. S. (2014) *Elementary and middle school mathematics: teaching developmentally.* Toronto: Pearson Canada.