Formal, non-formal and informal learning in the sciences

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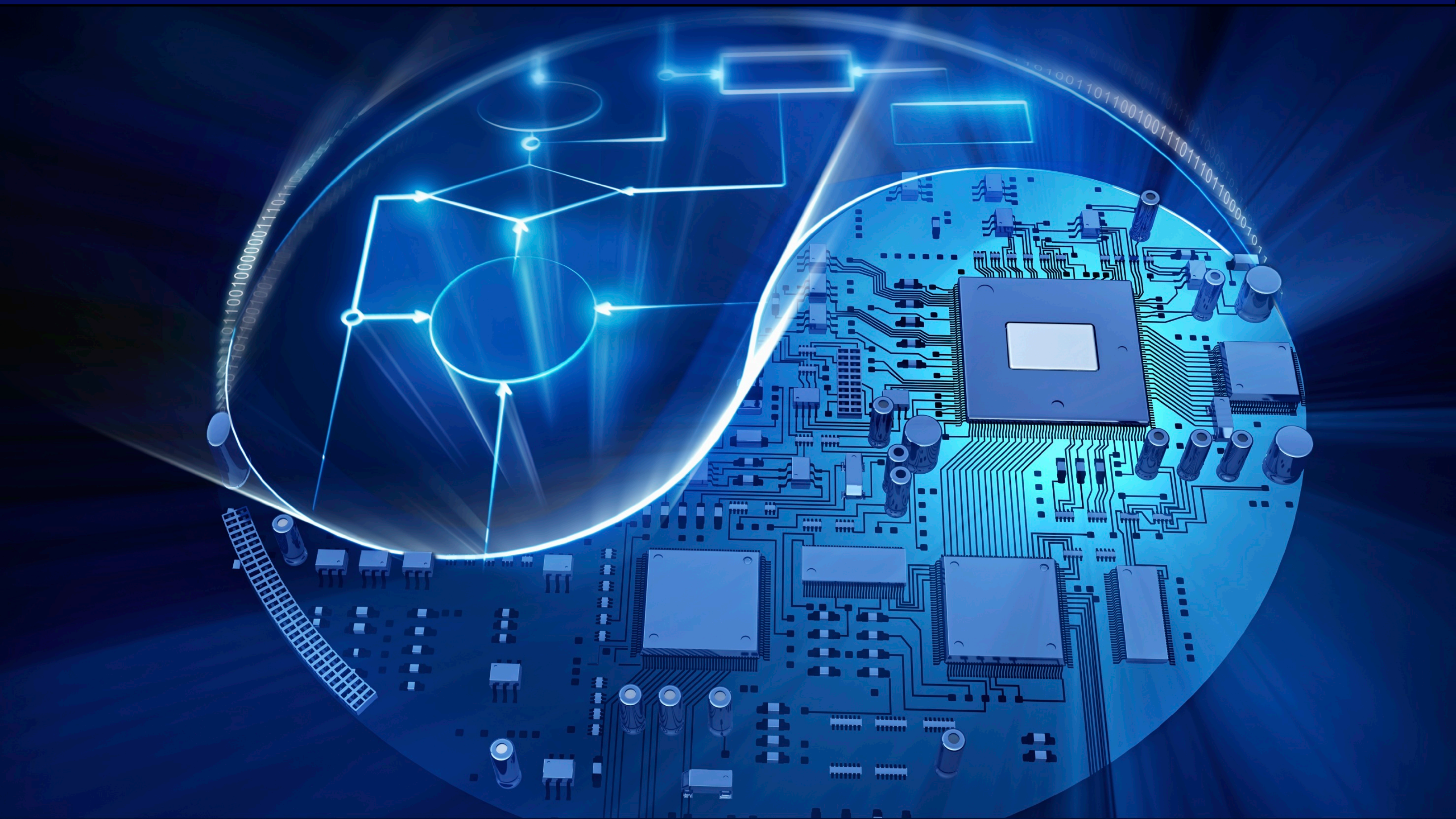

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The Case of Literacy, Essential Skills and Language Learning in Canada

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List of Acronyms

APEGGA	Association of Professional Engineers, Geologists and Geophysicists of Alberta
CMEC	Council of Ministers of Education, Canada / Le Conseil des ministres de l'Éducation (Canada)
HRSDC	Human Resources and Skills Development Canada / Ressources humaines et Développment des compétences Canada
OECD	Organisation for Economic Co-operation and Development / Organisation de Coopération et de Développement Economiques

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Executive Summary

This research report investigates the links between formal, non-formal and informal learning and the differences between them. In particular, the report aims to link these notions of learning to sciences and engineering in Canada and the United States.

Philosophical underpinnings of this research are:

- There is value in learning of all kinds.
- Learning is a lifelong endeavour.
- An interdisciplinary approach is valuable.

Notions of formal, non-formal and informal learning may be briefly outlined as:

Formal learning	This type of learning is intentional, organized and structured. Formal learning opportunities are usually arranged by institutions. Often this type of learning is guided by a curriculum or other type of formal program.
Non-formal learning	This type of learning may or may not be intentional or arranged by an institution, but is usually organized in some way, even if it is loosely organized. There are no formal credits granted in non-formal learning situations.
Informal learning	This type of learning is never organized. Rather than being guided by a rigid curriculum, it is often thought of experiential and spontaneous.

(Organisation for Economic Co-operation and Development / Organisation de Coopération et de Développement Economiques (OECD), n.d.; Werquin, 2007)

Examples are given for each of these types of learning in different scientific contexts, including basic scientific literacy at one end of the scale and professional organizations at the other end of the scale.

Introduction

This research report investigates the links between formal, non-formal and informal learning and the differences between them. In particular, the report aims to link these notions of learning to the field of sciences and engineering in Canada and the United States. It offers practical, concrete examples of each one in the context of these fields. It offers examples of how all three types of learning are valued in the fields of science and engineering in both educational and professional contexts.

This report draws from research in the fields of education, sciences, engineering, as well as a number of government documents. It seeks to the notions of of formal, non-formal and informal learning and in the context of science and engineering. The study focuses on the Canadian and American contexts. This is by no means intended to be an exhaustive study, but rather one that highlights certain examples for the purposes of understanding the concepts presented. Errors and omissions are entirely the fault of the authors, who welcome feedback on the work.

Conceptual framework

There are a number of assumptions that underpin the philosophical approach to this research and values that have guided it:

- **There is value in learning of all kinds**
  Whether learning takes place in a formal setting such as a school, a non-formal setting such as a community or cultural centre or an informal setting such as a home, all learning is good, and all learning is valuable. All learning contributes to an individual's growth, not only cognitively, but also emotionally and socially.

- **Learning is a lifelong endeavour**

  Learning does not stop when a person leaves school. There are those who never have the opportunity to attend school, but this does not mean that they do not learn. Learning can take place anywhere, any time and any where. Learning occurs throughout one's life span.

- **An interdisciplinary approach is valuable**

  Traditional learning institutions divide learning into subjects. This helps us organize how we obtain new knowledge. But it can also create silos. Professionals who work in one discipline often do not connect with others who work in different areas, even when those two areas are closely connected. Professionals who work in related disciplines can learn from one another and collaborate in order to learn more about the world in innovative ways.

How we understand learning

There are various ways to categorize *how* we learn. For example, individuals may be classified into those who learn in concrete ways, preferring examples over ideas; and those who learn in abstract ways, relating more to theory and ideas, rather than examples (Kolb, 1984). Another popular way to describe learning preferences is based on the VARK model designed by Fleming. The VARK model presents learning styles as visual (V), aural (also known as auditory) (A), reading and writing (also known as verbal) (R), and kinesthetic (K) (Leite, Svinicki, & Shi, 2009).

Categorizing learning helps educators and students understand the learning process. Usually, an individual will recognize his or her own learning preferences first, identifying which methods and styles are most effective. After an individual recognizes and understands his or her own learning preferences, it becomes easier to understand how others learn. By understanding individual learning preferences we can build tolerance of the various ways in which human beings acquire and retain knowledge. This can help us respect that there are various ways of learning and appreciate that each of these ways is important and valid.

Learning preferences describe how individuals learn. This paper examines learning from a different perspective, by examining the contexts in which learning takes place, and the levels of formality for learning situations.

- There is value in learning of all kinds.
- Learning is a lifelong endeavour.
- An interdisciplinary approach is valuable.

In the mid- to late 1990s, the Organisation for Economic Co-operation and Development (OECD) began to actively promote and recognize learning as a lifelong endeavour, taking a "cradle to grave" approach to learning. The OECD, along with other educational experts, broadly define the contexts in which learning occurs throughout one's life in these terms:

Table 1: Formal, non-formal and informal learning

Formal learning	This type of learning is intentional, organized and structured. Formal learning opportunities are usually arranged by institutions. These include credit courses and programs through community colleges and universities. Generally, there are learning objectives and expected outcomes. Often this type of learning is guided by a curriculum or other type of formal program.
Non-formal learning	This type of learning may or may not be intentional or arranged by an institution, but is usually organized in some way, even if it is loosely organized. There are no formal credits granted in non-formal learning situations.
Informal learning	This type of learning is never organized. Rather than being guided by a rigid curriculum, it is often thought of as experiential learning. Critics of this type of learning argue that from the learner's viewpoint, this type of learning lacks intention and objectives. Of the three types of learning, it may be the most spontaneous.

Adapted from: (Organisation for Economic Co-operation and Development / Organisation de Coopération et de Développement Economiques (OECD), n.d.; Werquin, 2007)

Though these are broad categories, they can be considered part of a spectrum of learning environments. There will be situations that fit in between the three categories. These allow for diverse opportunities for continued learning in terms of professional development and supplementary skills.

The field of science: an overview

Science is a diverse field, which, broadly stated, involves the study of various aspects of the natural world around us, and is split into many disciplines and sub-disciplines. A common characteristic of all scientific study is the method by which different problems are tackled. The scientific method follows a step-by-step process involving:

- Defining the objective or the problem
- Defining the hypothesis to test
- Considering the background knowledge and previous work in the field
- Choosing a method
- Completing the experiment
- Recording the observations and results
- Interpreting the results
- Drawing conclusions

The specifics of each step may vary depending on the field of study, but the general principle of how the problem is tackled will be similar. In all cases, objectivity is attempted. One tries to fit one's own interpretation to the data, rather than forcing the data to fit a preferred interpretation. Experiments are undertaken to add either to one's personal knowledge or the general body of knowledge. For this reason, it is important to be able to communicate one's findings.

Each sub-discipline has developed its own terminology and usage of words; these may vary considerably from specialty to specialty. For example, most people consider sand to be any small loose rock grains. To a geologist, sand is an unconsolidated particle between 0.0625 and 2.0 mm. To an engineer, sand is a rounded particle with a size range of 0.07 to 4.76 mm. From these examples, it is easy to see that specialization within the sciences does not encourage an interdisciplinary approach.

Professionals do not often connect and collaborate with those in related fields, which translates into lost opportunities for both generalists and specialists to learn from one another. Sometimes, truly innovative ideas come from a person who is not constrained by established scientific dogma. For example, Alfred Wegener, a German meteorologist suggested continental drift based on varied sources of evidence as well as a supercontinent Pangaea. His theory was first published in *Die Entstehung der Kontinente und Ozeane (The Origin of Continents and Oceans)* in 1912 and later expanded into book form in 1915 which was later translated into numerous other languages. At the time he released his book, his ideas were met with rejection and even ridicule and hostility by his peers ("Alfred Wegener (1880-1930)," n.d.) And yet his theory is widely acknowledged today as the basis of modern plate tectonic theory and Wegener himself is regarded as “a brilliant interdisciplinary scientist” ("Alfred Wegener (1880-1930)," n.d.)

Unconstrained by dogma, Wegener allowed his experiences and informal learning to inform his work and scientific inquiry. He went on several trips to Greenland to undertake first-hand research, and the learning that took place during these trips prompted him to start thinking in new ways. In Wegener’s case, his learning in informal contexts may have been a strong contributing factor in his ability to understand the world from a new perspective and think in innovative ways.

Scientific literacy

Scientific literacy a term that encompasses “what the general public ought to know about science” (Durant, 1993) , and “commonly implies an appreciation for the nature, aims and general limitations of science, coupled with some understanding of the more important scientific ideas and concepts” (Jenkins, 1999) and their relevance to people’s everyday lives. The American Association for the Advancement of Sciences (AAAS) defines science literacy as:

> being familiar with the natural world and respecting its unity; being aware of some of the important ways in which mathematics, technology, and the sciences depend upon one another; understanding some of the key concepts and principles of sciences; having a capacity for scientific ways of thinking; knowing that sciences, mathematics, and technology are human enterprises, and knowing what that implies about their strengths and limitations; and being able to use scientific knowledge and ways of thinking for personal and social purposes.(American Association for the Advancement of Science (AAAS), 1989)

The National Research Council has a slightly different definition:

> Science literacy includes certain key concepts in the natural sciences, as well as how science relates to mathematics, technology, and other human endeavours. Science literacy also includes an understanding of the nature of science as well as inquiry skills such as designing experiments, collecting and analyzing data and drawing valid conclusions from evidence. (National Research Council (NRC), 1996)

Both of these models attribute importance not only to knowledge of science, technology and mathematics, but also to inquiry and thinking skills.

One Canadian foundation’s definition echoes the same notions:

> Scientific literacy is an evolving combination of science-related attitudes, skills and knowledge that students need to develop inquiry, problem-solving and decision-making abilities, to become lifelong learners, and to maintain a sense of wonder about the world around them. (Foundation for the Atlantic Canada Science Curriculum, 1997)

The ability to think critically is not limited to the scientific community. It is noteworthy that critical thinking is now considered one of the essential skills defined by Human Resources and Skill Development Canada that are determined to be part of basic literacy, and necessary for a productive work life as an adult. Evaluating the validity of results is a task that scientists and members of the general public alike need to do frequently.

There is a debate as to whether scientific literacy involves *doing* or *using* science. Obviously, there is a difference between the scientific knowledge a scientist needs to practice science and the knowledge an individual needs to understand the scientific component of public issues and media reports. Members of the public need to know concepts and vocabulary, as well as critical thinking skills, to understand and evaluate the results and interpretations of scientific reports. Since the world is becoming more dependent on technology and science, science literacy is crucial for informed decision-making as well as understanding the potential - and potential abuses - of science.

The examples that follow highlight how the learning of science can be understood within the framework of formal, non-formal and informal learning contexts.

Learning throughout the life span

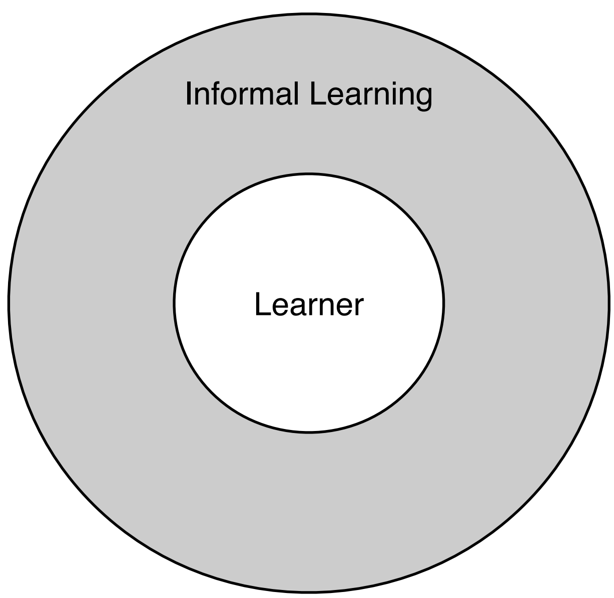
The way in which individuals learn and the contexts in which they learn will vary from person to person and region to region.

The diagrams below show how a person may learn in different contexts and how those contexts can change and expand throughout one's life. They are offered as descriptive, rather than prescriptive, ways of understanding informal, non-formal and formal learning throughout the lifespan.

Informal learning: Introduction to learning

Informal learning is likely to be the first type of learning a person experiences. As a baby, learning takes place spontaneously, all the time. Often guided by parents, grandparents, siblings and other caregivers, the world is a classroom and learning is all around us. The learner is literally immersed in learning from birth.

Figure 1: Informal learning: Introduction to learning



The figure on the previous page demonstrates how the learner is at the centre of the informal learning world, without need or want of formal classes. It should be noted that the diagram presents is a simplified way to understand the informal learning context. Although the diagram depicts the learner and learning as one circle within the other, in reality is the outer circle, the informal learning circle, could be borderless and limitless, as learning possibilities are not bounded by any particular restrictions.

A young person is immersed exclusively in informal learning during the time leading up to classes or programs that organize that learning. It is likely that the learner's first three to five years of life will be spent immersed in an informal learning environment.

During the early-childhood informal learning phase, learners will learn basic concepts such as:

- identifying (e.g. shapes, colours)
- classifying (e.g. cow, dog, cat, bus - Which one doesn't belong?)
- observing (e.g. watching a mobile turn or a bird fly through the air)
- testing and experimenting (e.g. If I poke this, what will happen?)
- counting
- measuring
- communicating

The introduction of non-formal and formal learning

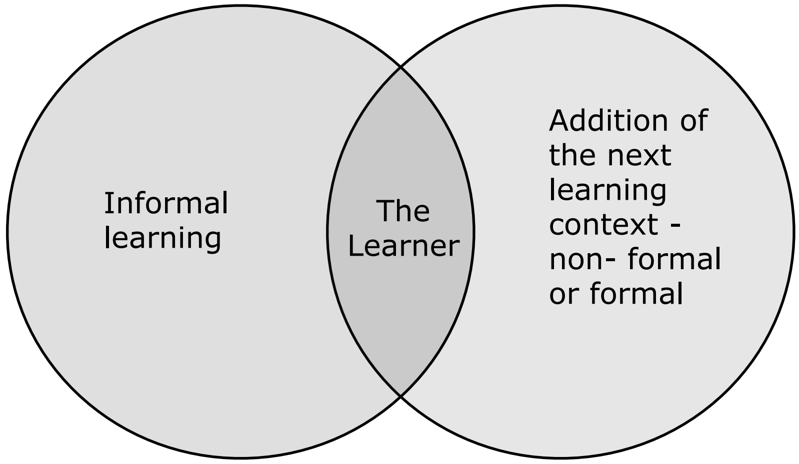
Once the learner begins to engage in organized learning, they enter the realm of either formal or non-formal learning. This occurs in developed countries where children have access to programs, teachers and resources.

The resources available in both the child's household and community may determine whether the child experiences non-formal learning or formal learning first. Many non-formal learning experiences for young children are operated on a fee-for-service basis. If parents or caregivers have the means to pay for the programs, children may take part. If not, the child may remain immersed in the informal learning environment until they enter school, the first formal learning experience.

Learning contexts at this young stage of life will usually be introduced one at a time; that is to say it is unlikely that a learner would go from being immersed in an informal learning environment to both a non-formal and formal learning environment at once.

This expansion of a child's learning experience from being immersed solely in an informal learning context to that of having both the informal and an additional learning context (either non-formal or formal) is shown on the next page.

Figure 2: The addition of formal or non-formal learning



Regardless of whether children experience non-formal or formal learning first, after being immersed in informal learning, the result is the same. Their learning begins to be guided and influenced by someone other than a caregiver. The learning becomes organized and structured, even if only loosely. Their experience as a learner becomes enriched as they enter a new learning environment.

Non-formal learning in sciences for young children

For many individuals, the next context in which they learn is a non-formal one. Learning is usually organized in some way, but without formal credits. Examples of non-formal learning for young children in include:

- play school or other environments offering organized play with a learning component
- parent-and-baby learning programs
- parent-and-tot learning programs
- classes, workshops and learning sessions organized by libraries, museums, science centres, zoos and other educational organizations

For example, the Ontario Science Centre offers a program called "KidSpark Hands-On Workshops" for children under 8 years of age, which they attend together with their caregivers. Children learn about concepts such as static electricity, planets in the solar system, and buildings and structures.

The Okanagan Science Centre, located in British Columbia, offers a program called "Silly Science for Preschoolers". This program is designed for children 3-5 years of age, which they attend together with their care givers. Its purpose is to "explore phenomena and materials that draw upon their natural curiosity, captivate, motivate, and prepare them for ideas important to later learning as well as having some 'serious fun'".

Calgary's Telus World of Science offers a "Little Learners Program" designed to "pique the curiosity for little learners" aged two to five. The programs focus on art, science and technology and include stories, music and hands-on activities.

Formal learning in sciences

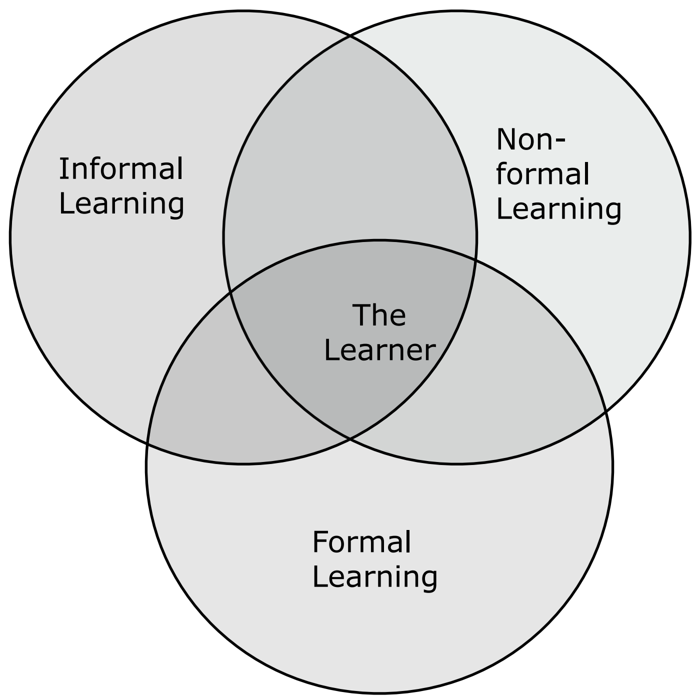
Children begin their formal learning in sciences in elementary school. By high school they specialize in subjects such as chemistry, physics and biology. By the time a learner graduates from high school, he or she has had the opportunity to acquire basic scientific literacy skills.

Following the completion of secondary or high school, a learner may opt for a career in a scientific field. Today this usually entails undertaking post-secondary studies at a polytechnic college or a university. Students can specialize in some aspect of science or engineering that will lead them in the direction of their desired career.

Integrated learning contexts

By the time a student has finished high school, not only should he or she have basic scientific literacy skills, but also it is likely that the learner will have experienced learning in a variety of contexts. Their learning experience will have expanded to include learning in informal, non-formal and formal contexts. This can be visualized in this way:

Figure 3: The Integrated Learning Context Model: Formal, Non-formal and Informal Learning



In this representation of the learner in the integrated learning contexts, it is easy to understand how the individual remains at the centre. The learner gains different knowledge and skills from each context and integrates them into his or her own personal knowledge centre.

Table 2: Formal learning in the sciences

Example - Science Degree Programs	Learning Context Characteristics
An example of learning in this context includes students learning fundamental sciences in school. The learning is organized and governed by the educational system's curriculum, which has learning outcomes and goals for all learners. Students are assessed on their learning at regular intervals, and they receive grades for their progress, which are then recorded and eventually reported in the form of report cards. University programs are usually structured such that students take basic courses in the fundamental sciences and higher level courses in their specialization or majors. The hope is that students will understand fundamentals and learn how to access and understand previous work. They also gain a theoretical knowledge base to inform and compliment practical skills and knowledge. Both lecture and laboratory components of university classes are examples of formal learning, though each has a very different structure and intent. Lab classes offer the opportunity for hands-on experience and experiential learning, while lectures are more theoretical in nature.	• Learning takes place in an organized manner, often following a curriculum or program. • Learning organizations, such as schools and academies, are accredited by the government. • Learning is often led by experts and trained professionals (e.g. Professors or teachers). • Learning is recorded and grades or credit are granted. • This type of learning is traditionally held in high regard, valued and considered credible.

Table 3: Non-formal learning in the sciences

<table>
<tr><th>Example #1 - Tutoring Services</th><th>Learning Context Characteristics</th></tr>
<tr><td>Tutoring services which offer one-on-one instruction are examples of non-formal learning. These classes are loosely organized, but not for credit. Students learn a great deal in terms of content and study skills from these classes, though these classes are not usually recognized by accredited institutions.</td><td rowspan="5">Learning may be formally or loosely organized.
Learning is more easily adapted to the individual learner's needs.
Learning is likely led by someone with more experience, perhaps a more advanced student, a volunteer, or an adult educator. This person may or may not have formal training as an educator.
This type of learning is sometimes considered less credible than formal learning.
Learning may involve skills that are transferrable to work in the learner's primary field of study.</td></tr>
<tr><td>Example #2 - Supplemental Skills</td></tr>
<tr><td>These are skills that are useful to one's research or formal degree program, but are not required by the university. Specific examples of these supplemental skills are avalanche safety training, scuba diving, rock climbing, first aid training and health and safety certifications.</td></tr>
<tr><td>Example #3 - Guided Programs</td></tr>
<tr><td>Guided programs at National and Provincial Parks or Historic Sites are also examples of non-formal learning, since an individual does not gain credit for attending these programs. These programs can enhance one's visiting experience of these protected areas and offer greater insight into the history and wonders of the natural world.</td></tr>
</table>

Table 4: Informal learning in the sciences

Examples	Learning Context Characteristics
Studying and learning with a study buddy or friend is an example of informal learning. This learning can take place anywhere and at any time as learners engage in conversation with one another. These discussions may clarify concepts introduced in formal or non-formal contexts or introduce new ideas entirely. A group of friends from a wide range of backgrounds and fields offer many learning opportunities. While hiking, one might learn plant identification from a gardener or botanist and learn about rock formations and fossils from a geologist. Another example is watching documentaries or National Geographic programs on television. IMAX films also offer the opportunity to investigate a topic and inspire people to continue learning.	• Learning does not take place in a formal setting. Learning can happen any time, and in any place. • Those leading the learning are more likely to be close to the learner (e.g. grand parent, parent, sibling, caregiver or friend.) • This type of learning is often overlooked as valid learning during the school years. It is the most difficult to quantify or track, but is essential to a young person's cognitive development. • Professional associations in the sciences often insist upon field experience for membership. This type of on-the-job or hand-on experience counts as informal learning.

Changing attitudes toward learning

It used to be that only formal learning that took place in accredited institutions, and verified by grades and transcripts, was considered credible. Non-formal and informal education were discounted or assumed to be merely an addition to a "proper" education.

The situation is changing in the 21st century. More and more non-formal and informal types of learning are being acknowledged, valued and even required as part of professional practice. For example, a report released by Alberta Education (2007, December 20) emphasizes the value of lifelong learning and community-based learning. It states that learning of all types helps to create "vibrant communities". Reports such as these give long-overdue credit to the non-formal and informal learning experiences that occur throughout a person's life.

The National Research Council has suggested that inquiry-based learning is necessary for improving scientific literacy, since theses "minds-on" activities are more effective than "hands-on" activities.

Popular media has also increased the general population's knowledge in some areas of science. For example, the "C.S.I. effect", named after the TV show (and short for "Crime Scene Investigation") has made forensic science popular and increased the general public's knowledge of this discipline. Viewers of television crime drama programs have learned about forensic science through informal, and even recreational, means.

> The 'CSI effect' has resulted in such an increase in informal learning about forensic science that jurors have increased their demand for sound evidence before making their decisions.

This has created both advantages and and disadvantages. While there has been increased enrollment in forensic science programs, there is now an increased expectation of jurors' understanding of forensic evidence in court proceedings (Dakss, 2005; Willing, 2004).

The ‘CSI effect’ demonstrates how a deeper understanding of a field or an issue can increase critical thinking skills and th demand for more sound evidence before legal decisions are made.

Attitudes toward learning are changing.

While it is likely that a formal education will continue to be highly valued, there has been an increase in the value placed on learning that takes place in non-formal and informal contexts.

The notion of lifelong learning, a concept once dismissed as unnecessary, is now generally accepted as both valuable and necessary. In 2009, the Canadian Council on Learning released its *Composite Learning Index: Measuring Canada’s Progress in Lifelong Learning* (2009). Lifelong learning is now a topic of interest not only among educators and researchers, but also among learners themselves.

The Atlantic Canada Foundation for Science Curriculum released a report in 1997 outlining its vision for science education for that region. The report called for the use of non-print resources, an increase in the use of technology and an emphasis on lifelong learning.

Even at universities, where formal learning has long been regarded as the most revered and prestigious type of learning, attitudes are changing. In 1971, scholar Robert Nisbet wrote *The Degradation of the Academic Dogma: The University in America, 1945-1970* in which he lamented the loss of what he claimed to be the essence of quality education in universities.

Nisbet’s traditional and arguably patriarchal views are now regarded as outdated, with institutions and individuals actively seeking new ways to integrate both non-formal and informal learning possibilities into traditional curricula. Other learning contexts are now regarded as an opportunity to enrich and deepen students’ understanding of their field.

Reforms to science education emphasize broadly overarching themes, rather than focusing on isolated facts and concepts. This tendency toward collaboration promotes general science knowledge rather than specific, specialized knowledge.

Bell and Lederman (2000) assert that it is not enough merely to educate students on scientific concepts, students need to why scientific ideas should be used, and to value its relevance to their everyday lives and decisions.

- All individuals have the capacity to learn.
- There are many different ways to learn.
- Learning continues throughout the life span.

Formal, non-formal and informal learning in the scientific and engineering professions

Professional organizations now encourage or even require their members to undertake continuing professional development. It is especially important to stay abreast of current developments in one's field to ensure that one's work is useful and valuable. Continued lifelong learning is a way to avoid stagnation and stay current regarding changes and innovations in the fields of science and engineering.

While traditionally formal education has been highly valued, other kinds of learning have are gaining more regard as constituting an important part of professional development. For example, the Association of Professional Engineers, Geologists and Geophysicists of Alberta (APEGGA) values formal, non-formal and informal learning which is highlighted through their membership requirements. Students who earn their degrees at the University of Alberta or the University of Calgary often fulfill the academic requirements to register as members-in-training; this is an example of formal learning. To become a member with a professional designation, one must have at least four years of experience. This demonstrates that APEGGA values the informal learning that takes place on the job through mentorship by experienced professionals. Continued professional development is an important part of maintaining one's professional designation and membership in APEGGA. This continued learning may take place in non-formal contexts such as in-house seminars, technical talks or short courses at conferences.

Table 5: Formal, non-formal and informal learning as requirements for membership in the Association of Professional Engineers, Geologists and Geophysicists of Alberta

APEGGA Membership Level	Requirement	Learning Context
Members-in-training	Must fulfill academic requirements, earned at an accredited and recognized university.	Formal Learning
Professional designation	Four years of professional experience.	Informal / Experiential Learning
Professional designation (maintenance)	Continued professional development in the form of seminars, short-courses at conferences, etc.	Non-formal learning

This is one example of how a professional association incorporates formal, informal and non-formal learning requirements for members. Prospective members must meet minimum formal education standards to be considered for membership, but schooling alone is not enough. Before being granted a full professional designation, members must have fairly extensive field experience. Full membership is attained when formal education has been complemented by informal, experiential learning. In order to remain a member in good standing, a professional must continue his or her education through professional development. The seminars and workshops that constitute this continuing professional development fall largely under the category of non-formal learning.

Thus we see how all three types of learning are integrated into the young and mature professional's career in this association.

This is a fairly standard structure for membership in scientific professional organizations. Professional engineering and geoscience organizations across Canada and the United States are nearly identical in terms of structure.

Interview with a new kind of learning expert

Dr. Susan Nash, the Director of Education and Professional Development for the American Association of Petroleum Geologists, graciously agreed to be interviewed for this study. When questioned about the the value of formal, non-formal and informal learning in sciences and engineering, she remarked:

> *All three types of learning co-exist because people learn in different ways, in different situations, and for different purposes. Learning styles vary; the context of learning is often heavily dependent on a clearly defined outcome or exigency, and one's learning goals are often related to a specific need, personal desire or business purpose.*

A formal education, in the form of a university degree, is now considered one component of the learning necessary for well-rounded and complete professional training. The inclusion of hands-on experience (informal learning) and continued education (also known as "continuing professional development", "non-credit education", "post-degree course work" or "non-formal learning") adds richness and robustness to the professional's understanding of his or her discipline.

Nash notes that the inclusion of non-formal and informal learning "helps graduates (whether recent or in the past) keep up-to-date in the science and newest technologies. It removes the pressure from traditional programs which can provide a foundation, but which do not have the capability of providing the latest (and very expensive) highly specialized technical / scientific education".

The interactive nature of e-learning enables worldwide collaboration within a community of interest. Nash believes that the future will have continued learning facilitated by technology, avoiding the need for costly travel.

Nash has found that courses related to licensure and other trendy topics are popular. Technology, such as the iPad or iPhone, as well as other emerging technologies, allow for interactive demonstrations and that incorporate different learning styles. An expert in e-learning and educational technology, Nash cautions that "it is important to avoid being mesmerized by the latest development in technology, which can often turn out to be an expensive and/or ephemeral fad."

She notes that such learning must be practical and applicable to the work of participants in the courses sharing new scientific research. This echoes the research of adult education expert Stephen Lieb, who asserts that two key principles of adult learning are that the material must be useful and relevant to the learner (Lieb, 1991). Nash points out that non-formal and informal learning that occurs using a technology platform does not mitigate the underlying need for increased critical thinking and reflection skills among professionals. She warns that there is a a risk of "learned helplessness which may result from an over-reliance on technology, without the engagement of a team and the need to think critically."

Trends in the evaluation of learning

The turn of the millennium marked a significant shift in how we recognize and value education. Now, learning of all kinds, whether it takes place within a formal school setting, a non-formal learning setting or a context that is completely informal, is seen as valuable. This demonstrates significant progress in how we view, understand and appreciate learning.

This calls for new and updated ways of evaluating learning.

There is a movement toward researching, developing and implementing learning frameworks in order to understand learning across a variety of contexts. The Council of Ministers of Education (CMEC) in Canada has developed a *Common Framework of Science Learning Outcomes* (1997) which seeks to guide conversations about science learning how it may be understood and assessed in the new millennium.

Learning inspires learning

When learning of all types is recognized and valued, learners are inspired to continue learning. Furthermore, when learners can see the real-world application of their skills they are more likely to understand why it is important to continue to build their skill and competence level. They see a use for learning beyond the formal classroom and understand that it is a lifelong endeavour.

Conclusions

The first decade of this new millennium has shown that we are opening our minds to new ways of understanding learning. The traditional ways of only valuing the formal learning that takes place in schools, universities and other institutions is quickly becoming outdated. Old paradigms around education are shifting. The new paradigms that are replacing them are more inclusive, more flexible and more applicable to the real world.

> The new ways of regarding learning transcend geographical borders, be they provincial or national, and reach far beyond traditional notions of learning. No longer is formal education the 'only' way.

We are living in an exciting time in terms of how learning is valued. There are widespread movements led by governments, scholars and educators toward establishing systems that value learning based on competence and skill levels. Moreover, these systems have real world applications, as they are applied on a large scale and empower learners to understand their own competence levels. At the same time, learners may find themselves motivated and encouraged to continue to build on the skills they already have.

The movement towards valuing formal, non-formal and informal learning is emerging in distinct and yet related realms - from science for young learners through to professional organizations that set quality standards for those earning their living a particular field. This may pave the way for increased dialogue, collaboration and further valuing of the work done in each of these disciplines.

The new ways of regarding learning transcend geographical borders, be they provincial, state or or federal. New ways of valuing learning also reach far beyond traditional notions of education. No longer is formal education the 'only' way. Now we have systematic and inclusive methods to demonstrate and recognize all types of learning - formal, non-formal and informal.

Appendix 1: National science and engineering organizations in Canada

Canadian National Organizations

Canadian Association of Geographers www.cag-acg.ca

Canadian Association of Geophysical Contractors www.cagc.ca

Canadian Association of Physicists www.cap.ca

Canadian Association of Zoos and Aquariums www.caza.ca

Canadian Astronomical Society www.casca.ca

Canadian Botanical Association www.cba-abc.ca

Canadian Coalition of Women in Engineering, Science, Trades and Technology

www.ccwestt.org

Canadian Council of Professional Geoscientists www.ccpg.ca

Canadian Exploration Geophysical Society www.kegsonline.org

Canadian Federation of Earth Sciences www.geoscience.ca

Canadian Forestry Association www.canadianforestry.com

Canadian Geophysical Union www.cgu-ugc.ca

Canadian Geotechnical Society www.cgs.ca

Canadian Institute of Mining, Metallurgy and Petroleum www.cim.org

Canadian Mathematics Education Study www.cmesg.math.ca

Canadian Meteorological and Oceanographic Society www.cmos.ca

Canadian Society for Bioengineering www.bioeng.ca

Canadian Society for Civil Engineering www.csce.ca

Canadian Society for Ecology and Evolution www.ecoevo.ca

Canadian Society for Epidemiology and Biostatistics www.cseb.ca

Canadian Society for Immunology www.csi-sci.ca

Canadian Society of Agronomy www.agronomycanada.com

Canadian Society of Environmental Biologists www.cseb-scbe.org

Canadian Society of Exploration Geophysicists www.cseg.ca

Canadian Society of Microbiologists www.csm-scm.org

Canadian Society of Petroleum Geologists www.cspg.org

Canadian Society of Zoologists www.csz-scz.ca

Chemical Institute of Canada www.chemistry.ca

Geological Association of Canada www.gac.ca

Prospectors and Developers Association of Canada www.pdac.ca

Royal Astronomical Society of Canada www.rasc.ca

Royal Canadian Geographical Society www.rcgs.org

Society of Petroleum Engineers www.ape.org

Appendix 2: Provincial science and engineering organizations in Canada

Provincial Professional Organizations

Association of Professional Engineers & Geoscientists of Saskatchewan

http://www.apegs.sk.ca

Association of Professional Engineers and Geoscientists of British Columbia

http://www.apeg.bc.ca

Association of Professional Engineers and Geoscientists of New Brunswick

http://www.apegnb.ca

Association of Professional Engineers and Geoscientists of the Province of Manitoba

http://www.apegm.mb.ca

Association of Professional Engineers, Geologists and Geophysicists of Alberta

http://www.apegga.org

Association of Professional Geoscientists of Nova Scotia

http://www.geoscientistsns.ca

Association of Professional Geoscientists of Ontario http://www.apgo.net

Northwest Territories and Nunavut Association of Professional Engineers & Geoscientists

http://www.napeg.nt.ca

Ordre des Geologues du Quebec http://www.ogq.ca

Professional Engineers and Geoscientists Newfoundland and Labrador

http://www.pegnl.ca

Appendix 3: Selected international science and engineering organizations outside Canada

These organizations support non-formal learning of literacy and essential skills, as well as other activities related to literacy such as advocacy and research.

International Organizations

American Association for the Advancement of Science

http://www.aaas.org

American Association of Petroleum Geologists

http://www.aapg.org

American Astronomical Society

http://www/aas.org

American Geophysical Union

http://www.agu.org

American Mathematical Society

http://www.ams.org

Association for Women in Science

http://www.awis.org

British Science Association

http://www.britishscienceassociation.org

Geological Society of America

http://www.geosociety.org

International Geoscience Education Organisation

http://www.geoscied.org

International Organisation for Science and Technology Education

http://www.ioste.org

National Earth Science Teachers Association

http://www.nestanet.org

National Marine Educators Association

http://www.marine-ed.org

Society of Petroleum Engineers

http://www.spe.org

Society of Exploration Geophysicists

http://www.seg.org

United Nations Educational, Scientific and Cultural Organization

http://www.unesco.org

Appendix 4: Other selected science organizations

University Organizations

Carl Wieman Science Education Initiative

http://www.cwsci.ubc.ca

Non-Profit Organizations

Centre for Affordable Water and Sanitation (CAWST)

http://www.cawst.org

Bibliography

Alberta Advanced Education and Technology (AAET). (2007, December 20). *Building vibrant learning communities: framework and actions to strengthen community adult learning councils and community literacy programs*. Retrieved from http://www.advancededandtech.alberta.ca/community/publications/vibrantlearning.aspx.

Alberta Advanced Education and Technology, G. o. A. (n.d.). Volunteer Tutor Adult Literacy Programs. Retrieved January 5, 2010, from http://www.advancededucation.gov.ab.ca/apps/literacy/volunteertutor.asp

Alfred Wegener (1880-1930). (n.d.). Retrieved May 1, 2010, from http://www.pangaea.org/wegener.htm

All-about-forensic-science.com. (n.d.). Understanding the CSI Effect. Retrieved May 10, 2010, from http://www.all-about-forensic-science.com/csi-effect.html

American Association for the Advancement of Science (AAAS). (1989). *Project 2061: Science for All Americans*. Washington, DC.

Bell, R. L., & Lederman, N. G. (2000). *Testing assumptions underlying the science education reforms: Decision-making on science and technology based issues*. Paper presented at the annual meeting of the American Educational Research Association.

Canadian Council on Learning (CCL). (2009). The 2009 Composite Learning Index: Measuring Canada's Progress in Lifelong Learning. Retrieved October 18, 2009, from http://www.nald.ca/library/research/ccl/cli/cli.pdf

Centre, O. S. (n.d.). Programs: Public Programs: Silly Science for Preschoolers. Retrieved May 10, 2010, from http://www.okscience.ca/programs.html

Council of Ministers of Education (CMEC) Canada. (1997). Common framework of science learning outcomes, K-12. Retrieved May 10, 2010, from http://openlibrary.org/b/OL17201701M/Common_framework_of_science_learning_outcomes_K-12

Dakss, B. (2005). The CSI Effect: Does the TV Crime Drama Influence How Jurors Think? Retrieved May 10, 2010, from http://www.cbsnews.com/stories/2005/03/21/earlyshow/main681949.shtml

Durant, J. R. (1993). What is science literacy? In J. R. Durant & J. Gregory (Eds.), *Science and Cutlure in Europe* (pp. 129-137). London: Science Museum.

Edmonton Catholic Schools. (n.d.). The Official and Second Languages Education Centre (OL2EC). Retrieved January 10, 2010, from http://www.ecsd.net/programs/ol2ec.html

Explore Program. (n.d.). Explore: Live the Canadian Experience. Retrieved January 15, 2010, from http://www.myexplore.ca/en/

Foundation for the Atlantic Canada Science Curriculum. (1997). Science Foundation. Retrieved May 10, 2010, from www.ednet.ns.ca/pdfdocs/curriculum/camet/foundations-science.pdf

Human Resources and Skills Development Canada. (n.d.-a). Essential Skills. Retrieved January 10, 2010, from http://www.hrsdc.gc.ca/eng/workplaceskills/essential_skills/general/home.shtml

Human Resources and Skills Development Canada. (n.d.-b). Understanding Essential Skills. Retrieved November 20, 2009, from http://www.hrsdc.gc.ca/eng/workplaceskills/essential_skills/general/understanding_es.shtml

Institute for Innovation in Second Language Education (Edmonton Public School Board). (n.d.). Retrieved January 10, 2010, from http://languages.epsb.ca/en/about-iisle/facts-about-iisle

Jenkins, E. W. (1999). School science, citizenship and the public understanding of science. *International Journal of Science Education, 21*(7), 703-710.

Kolb, D. A. (1984). *Experiential Learning: Experience as the source of learning and development*. Englewood Cliffs, NJ: Prentice-Hall.

Leite, W. L., Svinicki, M., & Shi, Y. (2009). Attempted Validation of the Scores of the VARK: Learning Styles Inventory With Multitrait–Multimethod Confirmatory Factor Analysis Models (pp. 2): SAGE Publications.

Lieb, S. (1991). Principles of Adult Learning. Retrieved October 15, 2009, from http://honolulu.hawaii.edu/intranet/committees/FacDevCom/guidebk/teachtip/adults-2.htm

Nash, S. E-learning Queen. Retrieved May 10, 2010, from http://www.elearningqueen.com/

Nash, S. (2010). Interview with Susan Nash, Director of Education and Professional Development for the American Association of Petroleum Geologists, on Formal, Non-Formal and Informal Learning in Sciences and Engineering (Interview conducted by Heather L. Ainsworth).

National Research Council (NRC). (1996). National science education standards. Washington, DC: National Academy Press.

Nisbet, R. (1971). *The Degradation of the Academic Dogma: The University in America, 1945-1970*. N.Y.: Basic Books Inc.

Ontario Science Centre. (n.d.). KidSpark Hands-On Workshops. Retrieved May 10, 2010, from http://www.ontariosciencecentre.ca/calendar/default.asp?eventid=630

Organisation for Economic Co-operation and Development / Organisation de Coopération et de Développement Economiques (OECD). (n.d.). Recognition of Non-formal and Informal Learning - Home. from http://www.oecd.org/document/25/0,3343,en_2649_39263238_37136921_1_1_1_1,00.html

Rehorick, S., & Lafargue, C. (2005). *The European Language Portfolio and its Potential for Canada (Proceedings of a conference held at UNB)*. Retrieved from http://www.unbf.ca/L2/Resources/PDFs/ELP/UNB_ELP_fullreport.pdf

Southern Alberta Heritage Language Association (SAHLA). (n.d.). Retrieved January 15, 2010, from http://www.sahla.ca/

University of Calgary. (n.d.-a). Leslie Reid: Experimenting with Science Education. Retrieved May 1, 2010, from http://www.ucalgary.ca/innovators/reid

University of Calgary. (n.d.-b). Tamaratt Teaching Professorship. Retrieved May 1, 2010, from http://people.ucalgary.ca/~tamaratt/Us.html

Wegener, A. (1912). *Die Entstehung der Kontinente und Ozeane (The Origin of Continents and Oceans)*.

Werquin, P. (2007). *Terms, Concepts and Models for Analyzing the Value of Recognition Programmes: RNFIL- Third Meeting of National Representatives and International Organisations*. Retrieved from http://www.oecd.org/dataoecd/33/58/41834711.pdf.

Willing, R. (2004). 'CSI Effect' has juries wanting more evidence. Retrieved May 10, 2010, from http://www.usatoday.com/news/nation/2004-08-05-csi-effect_x.htm

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Heather L. Ainsworth holds an M.Sc. in Geophysics from the University of Calgary. With her research background and scholarly record in both geophysics and geology, she has presented her work at scholarly conferences in her field and co-authored a number of works with research colleagues. In addition to having an impressive academic record, complete with accolades and awards, Ainsworth also has solid industry experience, having worked in the oil and gas industry for companies such as Imperial Oil and Encana. She currently serves as the Research and Programs Officer at Eaton International Consulting Inc., an internship position funded by the Career Focus Program of Service Canada.

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