UNIVERSITY OF ALBERTA

LEARNING IN PROFESSIONAL ENGINEERING AND EARTH SCIENCE: AN EXPLORATORY STUDY

BY

MICHAEL J. AHERNE ©

A thesis submitted to the Faculty of Graduate Studies and Research in partial

fulfillment of the requirements for the degree Master of Education

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The undersigned certify they have read, and recommend to the Faculty of Graduate Studies and Research for acceptance, a thesis entitled Learning in Professional Engineering and Earth Science: An Exploratory Study submitted by Michael J. Aherne in partial fulfillment of the requirements for the degree of Master of Education in Adult and Higher Education.

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DEDICATION

This thesis is dedicated to my parents John and Sheila. Through their hard work, sacrifice, continued support, and quiet encouragement they paved the way for opportunities which they never had. God bless them both, forever.

ABSTRACT

The purpose of this study was to establish how a changing professional work environment influences the learning activities professional engineers and earth scientists in Alberta use to maintain competent professional performance. To this end, an exploratory study was undertaken to establish which learning activities professional engineers and earth scientists in Alberta find important for developing and maintaining competent professional performance; what professional work environment conditions are important in maintaining competent professional performance; and what factors play a role in influencing learning in professional engineering and earth science practice. An objective of this study was to broaden understanding about contemporary professional learning as a guide for improving public policy decisions and educational practice.

A descriptive survey, administered through a questionnaire mailed to a proportional stratified sample of 400 members of the Association of Professional Engineers, Geologists, and Geophysicists of Alberta (APEGGA), was used for this study. The majority of questions were closed ended. The questionnaire was divided into four sections. It included questions about professional learner characteristics, the professional practice environment, demographics and current practice, as well as open-ended questions about improvements that could be made to professional development for engineers and earth scientists in Alberta.

The findings from this study indicated: 1) professional engineers and earth scientists in Alberta report informal learning in the workplace as most important for developing and maintaining competent professional performance; 2) sufficient time and opportunity to communicate internally with coworkers is the most important factor

reported for conducting work effectively; 3) there is a reported increase in complex engineering and earth science problems to which there are no easy solutions; 4) practice in an engineering, geological, or geophysical job is perceived as the most effective learning activity for professional practice; 5) respondents view APEGGA professional members as having a substantial individual responsibility for maintaining professional competence; 6) a majority of respondents oppose mandatory continuing education; and 7) greater overall employer support is desired by APEGGA professional members in assisting with continuing professional development.

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CHAPTER I

INTRODUCTION

The nature and rate of change impacting society and professions over the last half-century has been extraordinary. Practice-related knowledge in many technical fields, such as engineering and earth science has grown, and continues to grow, at geometric rates. Concomitantly, a growing awareness about public interest and safety issues, manifested by concern for the physical environment and technological changes' impact on society, fuels a complex public agenda in which professionals are compelled to positively respond (Curry, Wergin, and Associates, 1993; Sanford, 1989). Understanding the nature of sociopolitical, technological, and economic change which impacts professional practice is a first step for professional associations and continuing educators engaged in facilitating continuing professional development (Drucker, 1969). These changes have profound public policy and educational programming implications as they relate to understanding how learning facilitates professionals' capacity to maintain competent professional performance (Bennett and Fox, 1993; Sanford, 1989). Many approaches traditionally prescribed for maintaining professional competence, such as participation in continuing education, appear increasingly insufficient on their own for meeting the range of learning required in modern practice (Baskett and Marsick, 1992; Day and Baskett, 1982). Stakeholders with a direct interest in professional competence, such as governments, educators, professionals and their associations, are challenged to broaden their understanding of performance-oriented, professional learning. Along with this is the challenge of considering a variety of innovative approaches for effectively responding to more complex, ambiguous working environments which are characterized by rapid structural change (Drucker, 1995; Handy, 1994; Houle, 1980).

Researcher's Perspective on Continuing Professional Development

The researcher's perspective about contemporary continuing professional development is outlined in this section. In addition to original ideas the researcher developed while working with oil and gas professionals from some 55 countries, and healthcare professionals in a large active treatment hospital during an intense program restructuring and facility merger process, the researcher grounded his philosophical and conceptual approach in the work of several adult education scholars from the area of professional learning and change (Cervero, 1988; Day and Baskett, 1982; Fox, Mazmanian, and Putnam, 1989; Marsick and Watkins, 1990; Nowlen, 1988; Schön, 1983, 1987). A review of this section will enable the reader to understand the general direction which guided this study.

The education model (programming model) described by Tyler (1950) represents the dominant paradigm that has been employed in the education and training of professionals during preservice and continuing education (Belsheim, 1986; Day and Baskett, 1982). This model is no longer solely sufficient for assisting professionals to prepare for the ongoing learning requirements of a constantly changing professional work environment (Nowlen, 1988; Sanford, 1989). Formal modes of learning, manifested through educational programming, do not fully address the range of learning required and used to maintain competent professional performance (Kolb, 1984; Marsick and Watkins, 1990; Nowlen, 1988; Schön, 1983, 1987). Over reliance on the education model has also contributed to a perception that scholars, subject-matter experts, and educational programmers are the primary sources of legitimate professional knowledge (Schön, 1983, 1987). This has contributed to a lack of awareness, understanding, and recognition that professional practitioners are also sources of legitimate and highly valued professional knowledge (Cervero, 1992; Jarvis, 1994; Schön, 1983, 1987). To this end, Day and Baskett (1982) noted:

> 'Programmes' or 'learning activities' are usually planned and conducted by some kind of specialist...In contrast to the assumptions of the programme planning model, professionals learn to solve professional problems in a variety of ways, only one of which is participation in formal CPE programmes (p.145).

Professionals learn using a variety of techniques which transcend several learning modalities (Cervero, 1992; Nowlen, 1988; Schön, 1983). These modes include a range of formal and informal learning techniques (Marsick and Watkins, 1990; Watkins and Marsick, 1992). Therefore primary reliance and endorsement of formal learning methods for achieving continuing professional development goals appears to have limited utility for meeting important performance-oriented learning needs. (Baskett and Marsick, 1992; Nowlen, 1988).

One reason of the need for a broader understanding of professional learning can be partially explained by the profound nature of changes affecting contemporary professional practice (Drucker, 1995; Fullan, 1993). Handy (1989, 1994) has suggested a characteristic of post-industrial society involves discontinuous, structural change. Practices and adaptive strategies considered appropriate for times of incremental change appear to be much less effective for the nature of structural changes. These are the types of changes which are increasingly being reported in professional practice and they tend to require transformational responses rather than adaptive responses (ACEC, 1994; APEGGA, 1995, April; Fox, et al., 1989, Mezirow, 1981; 1991). Drucker (1982) partly explained this by noting that:

> Human nature has not changed much over recorded history. But the skills and the knowledge of the people, their work, and their jobs, their expectations - and also their life spans and their health - do change, and can change very rapidly. In no area, not even in technology, have the changes of the last thirty years been greater than in the workforce; and in no area will the changes be greater - or come faster - in the remaining years of this century than in the workforce - its composition, its working habits, its working life (p. 145).

Understanding the nature of change and practitioners' approaches to learning and change within a rapidly evolving professional work environment is required for stakeholders to effectively plan strategies that facilitate the development and maintenance of competent professional performance. To this end, the relative absence of theoretical perspectives that integrate change, its impact on professional practice, as well as the range of learning strategies professionals use to maintain competence may partially explain why the status quo, as defined by reliance on the education model, has been considered an acceptable and appropriate public policy and educational programming response for professional development (Cervero, 1988, Houle, 1980, Nowlen, 1988).

In considering strategies for facilitating professional development geared towards competent professional performance, the emphasis should clearly be on "learning rather than on the more customary term education chiefly because primary emphasis is on the actions of individuals and groups who seek to fulfill their own potentialities" (Houle, 1980, xi). Given the changing professional work environment practitioners encounter, effective continuing professional development must transcend the boundaries of time and space imposed by the education model (Nowlen, 1988; Sanford, 1989). Educators of professionals as well as associations and policy makers are challenged to understand continuing professional development that is oriented towards maintaining competent professional performance involves a range of complex, inter-related psychological and sociological dimensions (Baskett and Marsick, 1992; Garrison, in press). Effective policies and practice to facilitate continuing professional development must integrate these dimensions to be accepted as credible and useful by stakeholders (Houle, 1983; Wilson and Cervero, 1995).

Preservice and continuing education will continue to provide an important foundation for professional practice. To effect meaningful change, however, educators will be challenged to shift their emphasis in educational programming from the traditional education model to integrated models which are more flexible and aligned more closely with modern practice. Such approaches may incorporate elements of social change and problem-based models (Belsheim, 1986). To this end, important innovations in curricular philosophy and design within some professional schools, such as introduction of critical theory, active learning, and problem-based learning approaches, are beginning to take place (Brook and Wessel, personal communications, May 1995; Brookfield, 1993, Margetson, 1994).

For educational programming to be effective though, requires a much greater awareness and understanding how professionals incorporate learning from a range of sources into practice. This implies a need to more clearly understand how and where learning occurs in professional practice (Marsick and Watkins, 1990; Watkins and Marsick, 1992). It also involves understanding how learning is assimilated and transferred into practice with special attention to various factors in the professional work environment that trigger learning (Willis and Dubin, 1990). This ultimately invites exploration of several poorly understood transfer of learning questions. Indeed, recent discourse suggests "the process of becoming 'knowledgeable' is long, circuitous, and far more circumscribed and holistic than previously imagined" (Baskett and Marsick, 1992, p.12).

Continuing professional development, then is quite different than continuing professional education (CPE). Continuing professional education, however, is one of the vehicles for achieving continuing professional development goals. As Cervero (1985) points out though, CPE should in no way be conceived as the single variable which influences professional competence. Continuing professional development represents the continuum of formal and informal learning activities which professionals use to maintain competent professional performance in a highly context-laden, constantly changing professional work environment (Day and Baskett, 1982).

The need to evolve to a greater level of complexity in the approaches used to facilitate continuing professional development is a reflection of the characteristic complexity and ambiguity found in contemporary professional practice (Houle, 1983; Schön, 1983). In this sense, professional practice can be seen as evolving in its contextual dimensions with a corresponding requirement for continuing professional development responses to also evolve beyond the dominant tradition of the education (programming) model (Day and Baskett, 1982; Willis and Dubin, 1990).

The Contemporary Professional Work Environment

Understanding the nature of sociopolitical, technological, and economic changes as they influence the professional work environment is a basic tenant for understanding the need to shift to a broader conception of professional development.

Sociopolitical Factors

Paradoxes affecting professionals are becoming more pronounced (Handy, 1994; Kanter, 1989). It is increasingly difficult to consistently anticipate the consequences of professional actions as fundamentally new standards of ethical conduct emerge in response to changing societal expectations (Curry, et al., 1993; Schön, 1983). Practitioners find their professional autonomy under the threat of increased government regulation and they face greater likelihood of civil litigation for the professional actions which they undertake on a daily basis (Government of Alberta, 1990, June; 1991, May). Baskett and Marsick (1992) noted:

> Professions are subjected to an increasing array of pressures in today's turbulent society. This is also true for the nonprofessions, but professionals

> have held a privileged, almost sacred, role in society. Professionals are "supposed to be" more knowledgeable, ethical, socially oriented, and independent in their judgements than are nonprofessionals. It may or may not be fair to ask more of professionals, but society does so (p.7).

There have also been changing expectations of professional roles and conduct (Curry, et al., 1993; Sanford, 1989). A major shift has been a growing departure in the role of a professional from that of exclusive agent and advocate in prescribing professional interventions, to more of a role as partner and consultant in designing interventions for clients within a context of greater cost-control and increased practice constraints ascribed to public accountability. It has been argued that many of these sociopolitical trends contribute to deprofessionalization (Curry, et al., 1993; Houle, 1983).

This change in roles may be due, in part, to sociological factors beyond the control of professionals, such as an increase in overall educational levels and greater access to information by the general public. Through mass media, which includes an increase in higher quality educational television programming (i.e., Discovery Channel, The Learning Channel) as well as information publicly available on the Internet (Ogle, 1995), knowledge once the sole domain of professionals is now much more accessible to lay people.

One result of professional knowledge being more available in the public domain has been to alter the exclusive agency role of professional practice (Curry, et al., 1993). This places additional pressure on professionals to continually reevaluate their roles vis-à-vis the value they add through practice outcomes, in addition to their general service to society.

Professional work environments are also affected by micro (within a profession) and macro (external to a profession) regulatory and legislative changes. Increased government legislation in all facets of professional practice, from legislating the terms and conditions for licensing professionals, to establishing and regulating healthcare systems, building codes, and zoning restrictions, frame many of the sociopolitical parameters within which professionals must practice (Government of Alberta, 1994, August). McGuire (1993) noted that:

> Whatever the cause, it is apparent that ever greater reliance is being placed on formal administrative rules, government regulations, and court-imposed sanctions to control the behavior of professionals, to enforce standards in the quality of service they render, and to dictate their relations to each other and to the public they are pledged to serve (p. 14).

Heightened regulation in professional practice is an overriding concern for professional associations and their members (Curry et al., 1993).

Professional autonomy in self-governing professions, that being the privilege of practicing as a professional in good standing within the guidelines and codes of conduct established through peer review, also appears to be increasingly undermined (Curry, et al., 1993). An important dimension of continuing professional development involves professionals being ever vigilant of new practice standards (Sanford, 1989). As practice standards evolve, professionals must exercise compliance or face losing the privilege to legally practice as members in good standing of their profession. This can be difficult for individual practitioners as it often involves changing deeply-entrenched practice behaviors professionals believe have worked for them in the past (Argyris, 1977; Cervero, 1992; Jarvis, 1994). Methodologies and approaches once considered good practice are often considered inappropriate or less effective, as evidenced or defined by new knowledge, legislation or societal standards. Professionals are then faced with externally driven changes to which they feel professionally compelled or legally required to adapt (Fox, et al., 1989).

Technological Change and the Knowledge Explosion

The utility of much professional knowledge has also become temporally bound, due to a remarkable human capacity to rapidly generate new knowledge through innovations in basic and applied research. In fact, the concept of half-life has been adopted from nuclear physics to describe this process, in which a body of knowledge has utility for a limited time period before becoming outdated and replenished with newer knowledge (Dubin, 1990). McGuire (1993) suggested:

> Unless interrupted by some catastrophe, the volume of our knowledge, by its very nature, increases at a geometric rate. It is reliably predicted that our scientific and technical knowledge base, now doubling about every five to eight years, will soon begin to double every year in some fields...Professions based on the "hard" sciences (for example, engineering and medicine) will be the most affected, while those reliant on philosophy and/or theology (for example, the ministry) will be least impacted; others resting on the social and behavioral sciences (for example, law, teaching) will be somewhere in between (p. 8).

Growth in new professional knowledge has resulted in profound advancements in the capacity to effectively service client needs and address pressing societal issues. These advancements often offer the promise of more evidence-based interventions that can lead to better practice outcomes. Failure to recognize, understand, and incorporate new knowledge effectively into practice will inevitably result in more professionals facing professional obsolescence, thus increasing the incidence of performance problems (Dubin, 1972; Houle, 1980; Livneh, 1988; Nowlen, 1988). The essence of the continuing professional development quandary, however, is that many professionals appear to find it difficult to maintain knowledge and performance, relying solely on formal methods of learning such as their preservice university education or mandatory continuing education. Concomitantly, in an effort to demonstrate greater public accountability for professional competence, governments and many professional associations have often erroneously accepted approaches such as mandatory continuing education as legitimate public policy mechanisms for ensuring accountability for competent professional performance (Rockhill, 1983).

Economic Changes Impacting Professional Practice

Profound changes in the structure of organizations, industries, and the organization of work have become increasingly evident over the last decade (Drucker, 1993, 1995; Handy, 1989, 1994). The nature of changes in professional practice, many which appear to be driven by a broad agenda of economic determinism, were clearly articulated in a recent study commissioned by the Association of Professional Engineers, Geologists, and Geophysicists of Alberta (APEGGA). Issues reported in the *Structural Change and Professional Practice* study indicated that professionals were "working much longer hours, making judgments sooner, completing projects faster, and spending too much time on administrative work (APEGGA, 1995, April, p. 4-3).

A majority (77%) of APEGGA members surveyed reported that excessive pressure in the workplace was increasing the risk of mistakes and 70% of respondents believed the nature of the modern work environment required professionals be more consistently reminded about their professional responsibilities. Members also believed there were serious problems which existed in modern practice. They looked to APEGGA to be proactive is assisting members to respond. It was noted that: "Downsizing, restructuring, outsourcing, contract employment, and changes in technology are changing the way professionals work and how they are employed" (APEGGA, 1995, April, p. 1-2).

Some of the major structural changes related to economic factors which are affecting professional engineering and earth science practice in Alberta since 1986 include:

- Between 1988 and 1991, the eight major oil and gas producers (who accounted for almost 50% of exploration and production employment and almost 20% of APEGGA membership in 1988) downsized by 15%. Oil and gas service companies (drilling, well service, and geophysical companies) downsized by 24% and downsized their geologists, geophysicists and engineers by 29%.

- The major producers now contract about 10% of their staff. The smaller oil and gas firms contract 12%. But the trend is much higher. In 1994, KPMG reported that 28% of professionals in Calgary (including but not restricted to member professions) that obtained new employment were hired on term-specific contracts. Another 19% became self-employed.

- Large companies are turning to independent contractors for services they used to staff internally. They rely to a greater extent on consultants and contract staff to cover not only their peak but also much of their baseline requirements. This allows them to react more flexibly to changes needed in the volume or mix of skills. They can also spend less on training which becomes more of an expense and less of an investment.

- New forms of consultant/client relationships have emerged. Some clients have forged strategic alliances or partnerships with their consultants. Alliances enable the consultants to understand the client's systems and requirements almost like an employee and the client to have the benefit of the latest skills without the cost of training and downtime.

- Clients are demanding faster service without any reduction in quality. Production of designs are becoming a price competitive commodity sold by the hour.

- More non-engineering professionals are being employed by engineering firms. New organizational and ownership forms are resulting from client pressure, project financing needs, and increased employee participation - joint ventures, equity participation in projects, employee ownership, and broader profit sharing plans. Clients want total solutions, leading to new delivery structures and alliances with other service providers and conventional expertise alone is unlikely to win new contracts (APEGGA, 1995, April, p. 2-2, 2-3).

In a similar study (ACEC, 1994) relating to human resource issues in the Canadian consulting engineering industry, trends that were identified which influenced the business environment for consulting engineers included:

- The consulting engineering industry was undergoing continuing restructuring and redefinition. Causes included declining significance of public sector demand; higher financial risk on projects; intense competition and low profitability; increased competition from international firms; and similar rationalization and restructuring in client organizations.

- New opportunities for innovation and value-added in services exist which are being driven by new technologies, downsizing of clients' in-house groups, and cost-reduction pressures.

- Continuing conflict between the need to improve profitability while investing in continuing education and training, and responding to demand changes and increased competition.

- The use of contract employment arrangements to minimize costs and staff projects has also been increasing (ACEC, 1994).

The results of the APEGGA and ACEC studies suggest that economic factors contribute substantially to creating a much more complex professional work environment. An understanding of this emerging complexity is of paramount importance for stakeholders interested in crafting effective policies and processes for facilitating continuing professional development.

Professional Accountability and Competence: An Alberta Perspective

As with other legislative jurisdictions, professional competence has emerged on Alberta's public policy agenda as a matter of increased concern. This section considers recent policy directions of the Alberta government and the direction which the Association of Professional Engineers, Geologists, and Geophysicists of Alberta (APEGGA) have pursued in the area of continuing competence.

Policy Directions for Governing Professions in Alberta

Policy advisors have commented that "Alberta's existing system for professional legislation is complex and difficult to reform" (Government of Alberta, 1994, August, p. 6). Public policy efforts in Alberta over the last five years have included a pronounced move to structure legislation governing professional practice in a way that there is greater streamlining. Alberta's existing policy framework for governance in professional legislation was established in 1990. The objectives guiding the policy for developing Alberta's professional legislation are:

- The fundamental purpose of professional legislation is to regulate professions in the public interest.

- In order to promote the interests of the public, professional legislation shall establish standards, procedures and controls which, to the fullest extent possible:

    1. protect service users and the public from incompetent or unethical providers of professional services;

    2. promote quality, efficiency and cost effectiveness in the provision of professional services;

    3. balance the rights and responsibilities of professionals, service users and the public; and

    4. enable service users to exercise informed judgement and freedom of choice with respect to professional services (Government of Alberta, 1990, June, p.1).

Commenting on the efficacy of the policy in Alberta, the Health Workforce Rebalancing Committee noted:

> Revisions to bring existing legislation into line with the 1990 policy have been introduced whenever other changes were proposed to the legislation. This incremental approach has resulted in some progress, but several statutes and regulations do not yet meet the provisions. This case-by-case approach is not only time consuming but since each act is developed and amended separately, significant inconsistencies can result (Government of Alberta, August, 1994, p.6).

The nature of legislative changes over the last eighteen months in health professions in Alberta has been a source of concern within other professions, including the Association of Professional Engineers, Geologists, and Geophysicists of Alberta (APEGGA).

A Response for Professional Accountability: Continuing Competence

Prominent issues for APEGGA, related to the rapidly changing political dynamics surrounding professional legislation in Alberta, have encompassed a range of policy issues. These have been focused mainly in maintaining a high level of public confidence, through ensuring high standards of competence and professional practice; effectively addressing scope of practice issues with other practitioners, especially members of the Alberta Society of Engineering Technologists (ASET); and providing guidance to members during a period of profound structural change.

The Association of Professional Engineers, Geologists, and Geophysicists of Alberta has been responsive to a range of concerns expressed by stakeholders. APEGGA leaders noted their awareness of current trends illustrated in the *Mirosh Report* on principles and policies governing legislation in the health professions in Alberta (Government of Alberta, 1994, August). Two points of particular interest for APEGGA (1995, November) were:

> ...the government will become proactive when it comes to competency and that professional legislation shall establish a range of mechanisms designed to ensure that the registered or licensed practitioners maintain acceptable standards of competency and conduct (p. 6).

APEGGA leaders also suggested that an "overriding trend is to ensure public safety by ensuring compliance" (APEGGA, 1995, November, p. 6). An underlying assumption that was the knowledge explosion, which has had a large impact on technical professionals, has created a situation where professionals must continually battle to remain current with new technologies and learn to stay competent.

In January 1995, a lifelong learning subcommittee of APEGGA's Professional Development Committee (PDC) noted that continuing education was a subset of the larger issue of continuing competence and should be coordinated through APEGGA's Practice Review Board (PRB). The Practice Review Board is the standing body established to monitor and act on matters of professional conduct within APEGGA, in the Association's capacity as administrator of the *Engineering, Geological, and Geophysical Professions Act* of Alberta. The Subcommittee noted in their January 1995 report to APEGGA's governing council that:

> The Subcommittee believes it is essential that APEGGA be proactive and implement a voluntary program of continuing education and professional development for its members. The Subcommittee believes it is inevitable that such programs will be required in response to government and public pressure, and to a growing awareness and need among our own members. The voluntary program will lay the foundation for implementing a mandatory program, if necessary (APEGGA, 1995, January, p. 2).

APEGGA's governing council responded to the recommendations of the Professional Development Committee's recommendations by commissioning a taskforce (APEGGA Council motion 95-009) of the Practice Review Board (PRB). The mandate of the PRB Subcommittee on Continuing Competence was to give the PDC's lifelong learning subcommittee's report serious consideration on the topic of continuing competence. This prompted consideration by APEGGA regarding the need for deeper understanding about issues of where competence is developed, how it is maintained, and how it can be most appropriately facilitated by a variety of stakeholders including APEGGA, employers, educators, government policy makers and members.

In November 1995, The Subcommittee on Continuing Competence tabled a discussion paper on a broad range of continuing competence issues, including strategies for how APEGGA might respond to them. The Subcommittee members recognized that:

> APEGGA must be active and be seen to be active in the establishment of an enhanced approach to continuing competence for its members. The members, public, government, employers and clients are increasingly aware of the rate of change in knowledge based industries, and they require evidence that demonstrates the continued competence of our professional members. It is not enough to rely on disciplinary procedures or individual motivation or any other single factor. A practical program is required that balances the need for independent practice with the profession's responsibility to its stakeholders. (APEGGA, 1995, November, p.2).

Specific recommendations in the Subcommittee's report, which received broad distribution prior to final recommendations in the form of a discussion paper, were offered to APEGGA's governing council in February 1996. The recommendations included:

1. APEGGA implement a Continuing Competence Program.
2. APEGGA modify the Code of Ethics to expressly require a focus on continuing competence by members.
3. The Continuing Competence Program be built upon a base of Lifelong Learning comprising the following elements:
   - APEGGA fosters, promotes and provides recognition for professional development and lifelong learning activities;
   - **all members** must participate;

- program delivery coordinated with other trends in Canada and internationally to ensure viability in the global market place;
- established guidelines and standards for what constitutes effective lifelong learning;
- a variety of activities will be viewed as satisfactory in meeting the established guidelines;
- individual members are accountable for and take responsibility for meeting the guidelines;
- mandatory **recording** of activities is undertaken by all members to meet the guidelines; and
- **audit** of records on a random basis and in response to request by APEGGA.

4. The Permit to Practice obligations be presented in such a way as to ensure that the employer's responsibility to support the Continuing Competence Program is clearly identified in the Professional Practice Management Plan (PPMP).

5. The existing disciplinary and practice review procedures be used in ensuring compliance to the Continuing Competence Program.

6. An education and communication program be developed for the purpose of implementing the Continuing Competence Program, including communications with APEGGA's stakeholders (APEGGA, 1995, November, p.3).

The recent process APEGGA engaged in was consistent with one of its stated goals which is to "motivate APEGGA's membership to understand and project the value of engineering, geological and geophysical services to society" with the strategy of establishing "a position on mandatory continuing education for practicing professionals and to discuss in a public fashion the benefits realized by society through the continuing education of professionals" (APEGGA, 1995, July, p.1).

Purpose and Significance of the Study

The general purpose of this study was to identify specific learning activities in which professional engineers and earth scientists in Alberta engage to learn in response to changing conditions of their professional work environments. The primary objective of the study was to enhance understanding for public policy and education programming practice in the area of continuing professional development by adopting a broader conception of how, when, where development occurs. It appeared this study was the first systematic inquiry into the performance-oriented, learning activities of Alberta professional engineers and earth scientists. Primary factors considered within the study included opportunities for learning within the professional work environment, conditions of the professional work environment which influenced performance, as well as factors which influence learning in professional practice. The study was guided by the following problem statement and research questions:

> How does a changing professional work environment influence the learning activities professional engineers and earth scientists in Alberta use to maintain performance?

- Which learning activities do professional engineers and earth scientists find important for developing and maintaining competence?
- What professional work environment conditions do engineers and earth scientists find important in developing and maintaining competence?
- What factors influence learning in professional engineering and earth science practice?

The focus of this study involved investigating how and where learning in practice occurs and how it might be more effectively encouraged and supported. Relatively little research had also been done to uncover activities professional engineers and earth scientists found most effective in facilitating learning related to performance in practice. As Cervero, Miller, and Dimmock (1986) noted "we lack a systematic understanding of the ways engineers learn once they complete their pre-service training" (p. 112).

Significance for Public Policy

The Government of Alberta's public policy position to protect the public from "incompetent practitioners" is a value statement apparently made in the interest of protecting Albertans and the interests of Alberta (Government of Alberta, 1990, June, 1991, May). The primary mechanism for achieving this public policy goal has traditionally been through mandating continuing education. This study sought to highlight, however, that learning required to maintain competent professional performance likely transcends learning which is achievable solely through mandatory continuing education. This study also sought to illustrate that competent professional performance is a complex process encompassing a continuum of formal and informal learning (Marsick and Watkins, 1990). Mandatory continuing education as it has traditionally been conceived and practiced is not a singularly suitable policy option for ensuring the development and maintenance of competent professional performance (Cervero, 1985). This study informs policy development by highlighting that professional learning is a complex process that occurs in a variety of settings and takes a variety of forms.

Significance for Educational Practice

The results of this study are also useful for improving preservice university education and continuing professional development approaches in professional engineering and earth science. The study assists in reframing an understanding about the nature of activities engineers and earth scientists find most useful for learning, while providing insight on factors in practice which most directly influence professionals' learning. This study provides information which may be disseminated to professionals and those committed to professional development, so that more effective learning opportunities can be identified and facilitated. It also prompts consideration of approaches to continuing professional development which more closely mirror the complexity and sophistication of modern practice. The study invites further questions about how to more effectively integrate formal learning experiences so they may complement and reinforce the powerful range of informal learning which occurs in practice.

Definition of Terms in the Study

Several concepts, constructs, and terms were used throughout this study. To achieve consistency in meaning and usage as well as consistency with the established literature base, the following definitions were established for use in the study:

Competent professional performance refers to the execution of a skillful process relating to the actual behaviors of professionals in practice grounded in the demonstration of professional competence (Bennett and Fox, 1993; Schön, 1987).

Continuing professional development was defined as any formal or informal activity professionals engage in to maintain or enhance competence and performance in their professional practice (Houle, 1980; Marsick and Watkins, 1990).

Formal continuing professional development, also referred to as continuing education, involves structured, planned educational experiences occurring in dedicated learning settings. These would be most often described as seminars, workshops, training sessions, and formal courses (Sandilands, 1994).

Formal learning involves the domain of structured, planned educational experiences occurring in dedicated learning settings (Houle, 1980; Marsick and Watkins, 1990).

Incidental learning, often included as a subset of informal learning, is non-planned, unintentional learning which occurs as the "byproduct of some other activity, such as task accomplishment, interpersonal interaction, sensing the organizational culture, or trial-and-error experimentation" (Marsick and Watkins, 1990, p. 7).

Informal learning involves purposive and incidental learning, including various forms of self-directed learning, which occur outside formally-structured, institutionally sponsored, classroom-based activities (Knowles, 1975; Marsick and Watkins, 1990; Tough, 1971).

Learning is the process by which people gain knowledge, sensitiveness, or mastery of skills through experience or study and is a continuous process grounded in experience which implies that all learning involves relearning (Houle, 1980; Kolb, 1984).

Managerial competence was defined as encompassing the application of knowledge and skill that must be carried out so that technical engineering and earth science can be performed (APEGGA, 1981).

Practice outcomes are the anticipated results, or expected outcomes derived through the provision of professional intervention (Curry, et al., 1993).

Profession. For the purposes of this study, Boissoneau's (1980) definition of professions will be used. A profession can be interpreted as a cohort with "...a distinct body of knowledge, a desire for autonomy, restriction of entry into practice, a professional body for representation, peer review for evaluation purposes and continuing education needs" (p.2).

Professional competence, also referred to in the study as competence is defined using the Hall and Jones (1976) definition:

> Competence is acquired intellectual, attitudinal, and/or motor capabilities derived from a specified role and setting and stated in terms of performance as a broad composite domain of behavior and which is, in effect, an integration and synthesis of behavioral objectives as well as some elements of covert behavior. (p 29-30).

Professional engineer and earth scientist for the purposes of this study is a professional member in good standing of the Association of Professional Engineers, Geologists, and Geophysicists of Alberta (APEGGA).

Professional work environment involves the range of sociopolitical, technological, and economic contextual factors which frame the environment within which professionals interact and conduct their practice (Curry, et al., 1993; Fox, et al., 1989; Nowlen, 1988).

Public policy was defined as a "specific undertaking by government on behalf of the public" (Selman and Dampier, 1991, p. 156).

Technical competence was used to describe what was termed technical or pure engineering and the knowledge and skill which are necessary to competently practice such engineering. The same definition was used for geology and geophysics (APEGGA, 1981).

Assumptions

Several assumptions were made in this study. It was assumed professional associations and their members were concerned with issues of professional competence. It was also assumed engineers and earth scientists were continually engaged in maintaining competence and enhancing the quality of professional practice through a variety of formal and informal learning activities. It was assumed that there was a positive relationship between learning, as defined in this study, and competent professional performance. It was assumed professionals engage in different learning modes depending on the nature of particular problems they encounter. It was also assumed important learning occurs in practice which transcends the scope of preservice and formal continuing education.

Given the extent of formal preservice and continuing education that professional engineers and earth scientists in Alberta undertake, it was also assumed this professional cohort was, as a whole, highly motivated and directed largely by professional mission. It was furthermore assumed engineers and earth scientists were concerned about being able to effectively respond to changes in their professional work environment and were prepared to invest time and energy in activities enabling them to consistently perform a thorough, professional job.

It was further assumed the respondents would complete the research instrument truthfully, investing the time and reflection necessary to answer the questions honestly and accurately. It was assumed the research instrument would be a valid and reliable tool for gathering quantitative and qualitative information about how professionals incorporate learning into their practices to maintain competent professional performance.

It was also assumed professional engineers and earth scientists surveyed in this study had achieved a baseline level of professional competence and demonstrate performance to the standards defined by their licensing body such that they maintain good standing with the Association of Professional Engineers, Geologists, and Geophysicists of Alberta (APEGGA), their professional governing body.

Delimitations and Limitations

This study was delimited to those professional engineers, geologists, and geophysicists licensed to practice in Alberta as members in good standing with the

Association of Professional Engineers, Geologists, and Geophysicists of Alberta (APEGGA) in the period between November and December, 1995.

The study was limited, in part, by the nature of the methodology. A descriptive survey research instrument captures data in a relatively static manner. The data are therefore contextually and temporally bound. The study represents a snapshot of what was happening among APEGGA professional members during the time frame of this study. The research instrument was used to highlight characteristics of a larger, dynamic process involving complex, non-linear interactions. A further limitation was inherent in the data gathering process. Professionals tend to be subject to extreme time pressures which may affect the response to a descriptive survey. This method, however, was considered the least intrusive, most efficient means for gathering data from a sample of professional engineers and earth scientists for understanding the phenomena. This was an acceptable methodological approach for validating the transferability and reliability of concepts from a range of professions as they related to answering the research questions raised within the scope of this study.

The study may have also been limited by some sampling bias. There was some variation in age category demographics between the sample and the survey responses. The precise variation is presented in Table 4.1. Respondents in the 20 -29 age category and in the 40 - 49 age category respondended in slightly greater numbers than those in the sample who tended to be older. Those in the sample from Edmonton, Fort McMurray, and other locations in Alberta also responded at a marginally higher rate than represented in the sample, while those in the sample from the Calgary area responded 8.8% less than as represented in the sample. It may be that a category of APEGGA members employed in corporate, supervisory, and managerial roles were underrepresented. This limitation was unavoidable. During follow up phone calls, several members in the sample from Calgary indicated they had stopped responding to mail surveys as they felt inundated by work and personal paperwork.

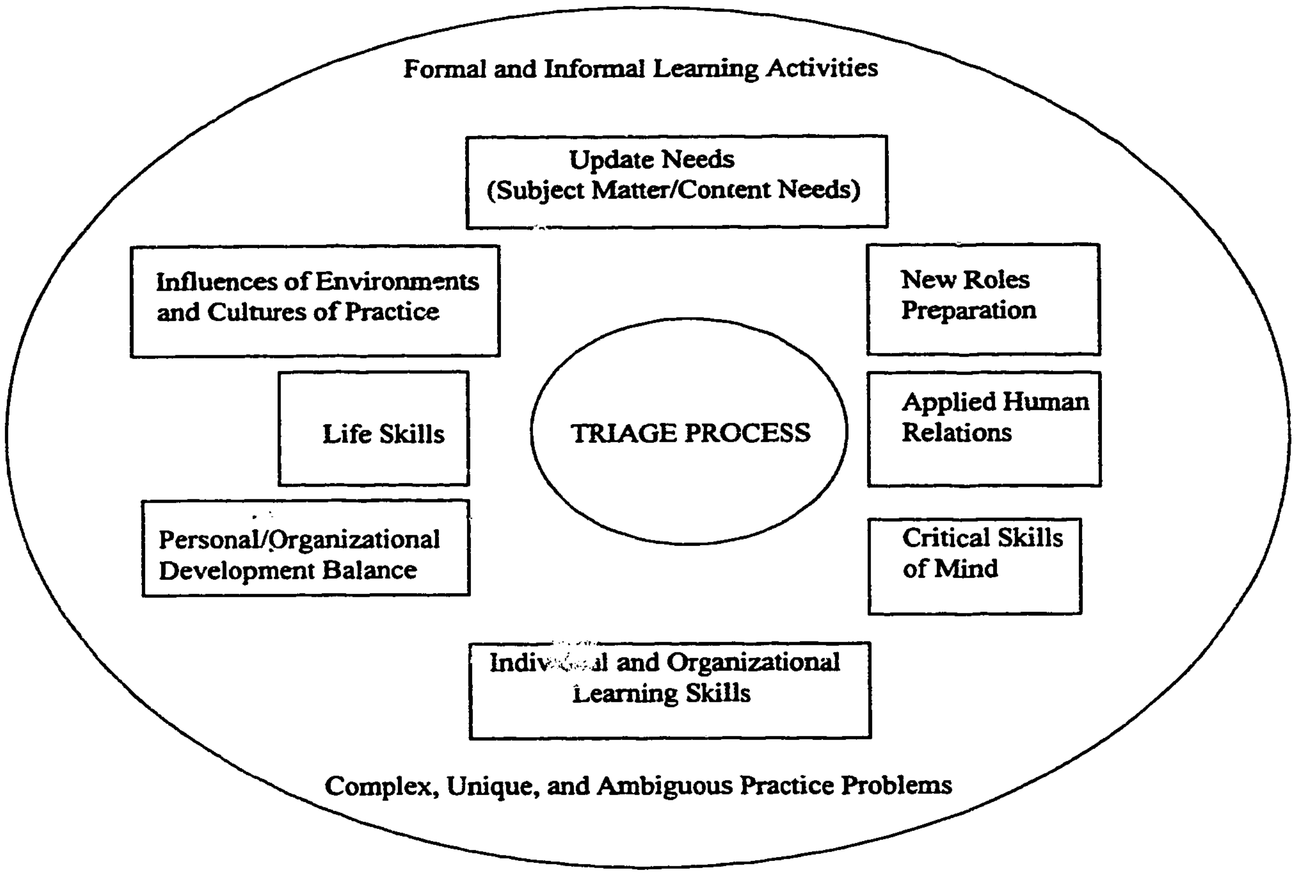
Conceptual Framework

A theoretical framework for understanding continuing professional development in professional engineering and earth science practice was proposed to guide this study. The first part of the framework draws on Nowlen's (1988) performance model of continuing professional education. This model is based on an awareness that competent professional performance cannot be fully understood through the decontextualized individual (Blanchard, 1990). Nowlen (1988) suggests performance "...is structured by a double helix in which there are two complex interactive strands, each bearing only part of the performance code. One carries cultural influences, the other the individual's characteristics" (p. 73). Therefore, "...the double helix of performance is the interaction of culture (including the psychological environment as well as the organizational) with the individual" (Nowlen, 1988, p. 95). Culture is taken to mean the context or network within which individual meaning-making and personal growth takes place. This is captured in this study primarily through the use of the term professional work environment, even though personal and professional dimensions cannot and should not be readily separated and decontextualized.

In the performance model practitioners and their organizations engage in a guided self-assessment, referred to as a performance triage (Nowlen, 1988). The focus of triage involves an examination of job functions; baseline knowledge and skills; the challenge of new roles; requisite skills in human relations; critical skills of mind; proficiency in self-managed learning; individual developmental progress, organizational development balance, and the fit of individual and organization; skills in coping with life's surprises and its anticipatable transitions; and understanding the influences of environments and cultures and the skills to orchestrate them (Nowlen, 1988). The outcomes of the triage analysis are learning and development agendas which can be met by a variety of formal and informal means.

The second part of the framework emphasizes that the nature of the contemporary professional work environment (Fox, et al., 1989; Matthias, 1991; Nowlen, 1988) and the complexity of problems encountered in practice (Schön, 1983, 1987), will dispose practitioners to be more inclined to report procedural knowledge (Cervero, 1992) derived through informal means of learning (Marsick and Watkins, 1990) as important for achieving practice outcomes and demonstrating competence (Sanford, 1989).

Figure 1.1 Integrated Professional Development Framework



Adapted from Nowlen, 1988, p. 87

Combining Nowlen's (1988) Performance Model of continuing professional education, Fox, et al.'s (1989), Matthias' (1991) and Schön's (1983) analysis on the changing nature of the professional work environment, and Marsick and Watkin's (1990) work on informal and incidental learning prompted the researcher to propose an integrated approach to continuing professional development. Such an integrated approach to professional development has the following features. It combines all the dimensions of Nowlen's (1988) performance model with an assumption that professionals engage in a range of formal and informal learning to develop and maintain competent professional performance.

An integrated approach to continuing professional development does not favor one mode of learning over another (i.e., formal versus informal). It assumes learning occurs on a continuum ranging from formal to highly informal (i.e., incidental learning). An integrated approach to professional development recognizes that practitioners are unique individuals, subject to the influences of personal and professional pressures inherent in their professional work environment. It also recognizes that practitioners learn in a variety of ways which may be mitigated by a poorly understood, complex, interactive mix of factors. The goal in integrated professional development, then becomes one of focusing on performance-oriented outcomes, while recognizing and enabling rich informal learning to occur as part of a seamless, ongoing individual and collective developmental process.

An integrated approach to continuing professional development focuses on finding an effective blend between formal continuing professional development activities (based on the education model), while integrating these with informal learning which occurs in practice. A goal in this process is to focus explicitly on the design of formal continuing professional development activities which maximize opportunities for the transfer of learning to occur from formal settings to the setting of the professional work environment.

Integrated professional development also recognizes the practitioner as an important, legitimate source of professional knowledge. In this sense, practitioners have active roles to play in the creation and dissemination of knowledge in formal continuing professional development situations. They also have important roles to play as critical consumers of knowledge and information presented within continuing professional development settings.

Integrated professional development, then, should not be considered to be a profound new approach to professional development. It represents an attempt by the researcher to inform continuing professional development practice by offering a more descriptive approach as to how professionals appear to learn, rather than the more normative approach contained within the established discourse of the field of Continuing Professional Education. In this sense, the researcher believes the proposition of an integrated model of continuing professional development to be a positive contribution to educational practice. As Kenny and Harnisch (1982) noted "...research in the applied field of adult and continuing education must be accountable in terms of the contributions it can and does make to the improvement of practice" (p. 29). As Houle (1983) suggested the next stage in the evolution of the field of Continuing Professional Education would most likely be an emphasis on the quality of professional performance. An integrated approach to continuing professional education represents one piece of a large puzzle regarding how and where professionals learn, as it relates to the development and maintenance of competent professional performance.

Organization of the Thesis

This thesis is organized into five chapters. The first chapter outlined the rationale and context for a study into the nature of learning in professional engineering and earth science in Alberta. The purpose and significance was also highlighted. Furthermore, the definitions, assumptions, delimitations, limitations, and conceptual framework used to guide this study were presented in Chapter I.

Chapter II presents a review of literature relevant to this study. The review is organized into three sections. First, the nature of change and the contemporary professional work environment are examined. The nature and domains of professional learning are then discussed. Finally, concepts related to proficiency, competence, and performance are highlighted.

Chapter III outlines the research methodology used for this study. An explanation of the descriptive survey method, the research instrument, pilot testing, sampling, and the data collection process is presented. A discussion of how the data was organized and prepared for analyses concludes Chapter III.

Chapter IV includes a presentation of the data gathered through the process outlined in Chapter III. The data analyses are organized and presented according to the three research questions which guided the study. A final section of Chapter IV outlines qualitative data analyses from the open-ended questions.

Chapter V presents a summary and discussion of the findings from Chapter IV. Implications for public policy and educational practice are also discussed. Suggestions for further research are presented as well as concluding comments.

CHAPTER II

REVIEW OF THE LITERATURE

The literature review for this study was conducted using two strategies. The first strategy involved a purposeful literature search of topics related to continuing education. This search focused on the reasons professionals engage in continuous learning and included an analysis of the methods they use. It encompassed a review of literature primarily from healthcare disciplines. Medicine and other health professions present a rich vein of research related to professional learning and change. The researcher perceived much of this work to be transferable to professional engineers and earth scientists. The process used for this part of the review was done by analyzing sources cited in earlier theses in the area and by a search of the ERIC database from 1984 - 1994.

A second strategy for the literature review involved reference to seminal sources in the area of professional learning and change. Drawing upon these two complementary strategies, the researcher proposed a conceptual framework which suggests professional engineers and earth scientists learn through a complex continuum of formal and informal activities as a function of, and in relation to, their interaction with a multitude of influences in their professional work environment. Learning that facilitates professional competence and in-practice performance supersedes the domain of formal learning on which traditional continuing education approaches have tended to rely. Continuing learning from this perspective requires a broader awareness about the nature of learning in the professional work environment. To engage in discussion about professional learning and change, literature from several subsets of the adult and continuing education field, such as reflective practice, informal and incidental learning, as well as critical thinking and problem solving were also referenced.

The Nature of Change and The Professional Work Environment

Two major areas which affect professional competence include the manner in which professionals adapt to change and a myriad of factors operating in complex and dynamic professional work environments.

The Nature of Change

One of the major life forces people struggle to adapt and respond to is change. Peters (1986) indicated that Rosenblum and Louis (1981) had identified what they described as two major approaches to organizational change. The first conceived change as "a rational, managable process where change takes place as a result of deliberate choices being made" (Peters, 1986, p.19). The other major perspective was the natural systems perspective which "allows for the inclusion of non-rational factors, such as norms and beliefs and existing organizational structures and practices, which may be less amenable to a planned, managed approach" (Peters, 1986, p.20). It is the natural systems perspective of change that presents itself as the most closely aligned conception of change relevant to this study. This is highlighted by Drucker (1995) who recently suggested:

> No century in human history has experienced so many social transformations and such radical ones as the twentieth century. They, I submit, shall turn out to be the most significant events of our century, and shall be its lasting legacy. In the developed free-market countries - only one-fifth of the earth's population, but the model for the rest - work and work-force, society and polity are all, in the last decade of this century, qualitatively and quantitatively different both from those of the first years of this century and from anything ever experienced before in human history: different in their configurations, in their processes, in their problems, and in their structures (p. 213).

Indeed, many changes in society have been transformational, yet the way change has been conceived has largely been incremental. Champy (1995) suggested:

> Incremental change is what we are used to: the kind that we could manage gradually, with careful planning, broad consensus-building, and controlled execution (p. 8).

Conceiving change as something that can be managed and controlled appears to be naive in a world characterized by much greater specialization and pluralism (Fullan, 1993; Handy, 1989, 1994). In fact, Handy (1989) noted:

> Today we know that in many areas of life we cannot guarantee more of the same, be it work or money, peace or freedom, health or happiness, and cannot even predict with confidence what will be happening in our own lives (p. 7).

As the Twenty-first century rapidly approaches, Handy's comments remain consistent with what Alvin Toffler (1970) predicted:

> In the three short decade between now and the twenty first century, millions of ordinary, psychologically normal people will face an abrupt collision with the future. Citizens of the world's richest and technologically advanced nations... will find it increasingly painful to keep up with the incessant demand for change that characterizes our time. For them, the future will have arrived too soon (p.11).

Handy (1989) suggested conceptualizing today's most profound structural changes in terms of discontinuous change. Discontinuous change has its roots in the mathematical tradition of catastrophe theory, that being "the study of discontinuous curves in observed phenomena, graphs that loop on themselves or go into precipitous falls or unsuspected plateaux" (p. 7).

Fullan (1993) advocated that professionals become comfortable with the concept of discontinuity. He noted "complexity, dynamism, and unpredictability, in other words, are not merely things that get in the way. They are normal!" (p. 20). In the context of continuing professional education, Johnson (1987) cited work done by Watzlawick, Weakland, and Fisch (1974) who described change as "a shift, a jump, a discontinuity or transformation" (p. 32).

Fox, et al. (1989) suggested there are essentially four types of professional change. These four types of change fall within three categories which Fox and his associates labeled accommodational (accommodations), incremental (adjustments), and structural (redirections and transformations).

Accommodations were seen to require small and simple acts of acceptance. This type of change was most likely to be a response to social or professional forces, such as a change in regulations to which one is professionally bound to adhere. These changes are highly focused and seldom go beyond the immediate area in question to other aspects of behavior or attitude. Compliance tends to be rapid and simple, with a neutral or somewhat irritated response. Most accommodations require little new learning to affect change (Fox, et al., 1989).

Incremental changes, in the form of adjustments, were identified as passing with little emotion. These changes require more complex adaptation and more time and effort to accomplish. They are often associated with adjustments to a particular practice intervention, method, or administrative procedure. Adjustments are also characterized by an active assessment of the disparity, or fit, between what is and what ought to be, by considered and purposeful behavior directed towards that end. Purely professional considerations, such as a desire to increase competence or respond to a change in the professional work environment, accounted for these types of changes and entailed some learning (Fox, et al., 1989).

Redirections are characterized by adding, subtracting, or changing a major element of a practitioner's personal life or professional practice. These changes are generally accompanied with moderately to strongly positive feelings. An example of a redirection may involve a practitioner who abandons an area of practice due to extreme external factors which create a high risk practice environment. Redirections are usually a response to personal forces. In the study of physicians, curiosity and a desire for personal well-being accounted for nearly 25% of the redirected changes reported by respondents. Substantial learning was reported in nearly 75% of the redirections (Fox, et al., 1989).

Transformations require restructuring and redefinition of multiple elements in a practitioner's personal and professional life. Such changes could involve a practitioner choosing to redefine the nature of their professional working relationships, with the subsequent impact this has on all aspects of personal and professional life. An example of this type of change in professional engineering and earth science practice would be the trend of having senior engineers and earth scientists leave long time employers for practice that is essentially characterized as an independent practice (APEGGA, 1995, April). Transformations were rare in the physician study, but only one in 27 transformations was a response to a purely professional force. The learning that was reported tended to be time-consuming, complex, and conceptual in nature (Fox, et al., 1989).

The typology of change identified in Fox, et al.'s *Learning and Change in the Live of Physicians* study was a major contribution to the field of professional learning and change. Until this study, changes in professional practice were viewed as relatively homogeneous. This expansion in the understanding of change is a key dimension in uncovering the complexity of the modern professional work environment.

Fox et al. (1989) noted most professionals see change as a routine part of life. It was discovered that professionals see change as a prerequisite for competent performance, as a means to achieve life and career goals and, occasionally, "as a response to the unwelcome pressure of modern times (Fox, et al., 1989, p. 4). Triggering events or catalysts, such as the introduction of an innovation in technology or a particular practice problem were seen as important agents for engaging professionals in learning (Fox, et al., 1989).

The Professional Work Environment

Modern professional practice is complex, dynamic and riddled with a myriad of quandaries (Cervero, 1988; Curry, et al., 1993). A crisis in public confidence has heightened the issue of professional competence across a range of professions (Sanford, 1989; Schön, 1983, 1987). Schön (1987) noted:

> In the varied topography of professional practice, there is a high, hard ground overlooking a swamp. On the high ground, manageable problems lend themselves to solution through the application of research-based theory and technique. In the swampy lowland, messy, confusing problems defy technical solution. The irony of this situation is that the problems of the high ground tend to be relatively unimportant to individuals or society at large...while in the swamp lie the problems of greatest human concern (p. 3).

In this light, understanding social and political dimensions within the professional work environment is central to professional competence (Curry, et al., 1993). Most approaches to professional competence incorporate underlying assumptions that performance is solely a function of the individual practitioner. Nowlen (1988) has severely critiqued this approach by arguing matters of competence extend beyond individual practitioners. The argument has been made that competence is a function of both the individual practitioner and the complex environment within which they operate (Bandura, 1977; Ross and Nisbett, 1991). While an individual practitioner may be competent in a given situation, factors in the professional work environment may prevent the same practitioner from demonstrating competence in another situation despite the practitioner possessing the same knowledge, skills, and affective traits in both contexts. Baskett and Marsick (1992) suggested:

> Professionals do not work solo but are part of an "ensemble" that involves relationships with peers, the organization through which service is delivered, paraprofessionals on whom the professional depends to meet client needs, legislation, community concerns, and professional associations to name but a few components (p. 8).

Bandura (1977), whose work on reciprocal determinism oversimplifies the complexity of modern practice and whose philosophical perspective is entrenched in behavioral psychology, nevertheless provides important insight into the dynamics operating between the practitioner and the professional work environment. He suggested:

> Environments have causes, as do behaviors. It is true that behavior is regulated by its contingencies, but the contingencies are partly of a person's own making. By their actions, people play an active role in producing the reinforcing contingencies that impinge upon them... behavior partly creates the environment, and environment influences the behavior in a reciprocal fashion (Bandura, 1977, p. 203).

In a similar tradition, Ross and Nisbett (1991) highlighted Kurt Lewin's (1951) work on situationism and channel theory. They suggested:

> Thus the main point of Lewin's situationism was that the social context creates potent forces producing or constraining behavior...An equally important part of Lewin's situationism was a healthy respect for apparently minor but actually important details of the situation. He called these "channel factors" because they referred to small but critical facilitators or barriers (p. 9-10).

When incorporated with Fox, et al.'s (1989) change typology, the importance of the channel factor principle becomes apparent. The nature of a change and its external catalyst appear to have an important relationship. When triggers or interventions, such as formal continuing professional education are employed, they may have little or no effect on changing practice behaviors, particularly if there is a significant affective dimension involved in changing behaviors. This may be in large part, due to an individual practitioner's interpretation of the value of an intervention as filtered through his or her professional value set, (i.e. professionalism). This includes highly valued perceptions about what works in practice (Cervero, 1992; Jarvis, 1994). In fact, it has been suggested:

> The channel factor principle, thus, is one key to understanding why some situational factors have bigger effects than might be anticipated and why some have smaller effects. Seemingly big interventions and campaigns that provide no effective behavioral outlet channel in the form of clear intentions of plans, will generally produce disappointingly small effects. And seemingly small situational factors that operate on important input or output channels will often exert gratifyingly large effects (Ross and Nisbett, 1991, p. 11).

Lewin's (1951) work on channel theory is reflected in what Cervero (1985, 1988) also suggested, in that single variable models of professional competence (where the lone independent variable influencing performance was a continuing professional education intervention) have been incomplete representations of a more complex process.

Lewin's (1951) channel theory in part, serves to explain the limited utility of continuing professional education in the programming tradition. It appears a clearer understanding of key triggers or influencers for professional learning is required (Fox, et al., 1989). A greater understanding of the interaction and interrelationships between practitioners and their professional work environments may also provide greater insight into how professional competence is developed and maintained (Nowlen, 1988). This analysis is consistent with what Belsheim (1986) advocated in his critique of the education model of continuing professional education.

The professional work environment and its role in facilitating competence was illustrated in a Canadian study of male professional engineers, physicians and pharmacists. Matthias (1991) found:

> The responses from the subjects convinced the researcher of the important roles the workplace, peer interaction and feed-back from patients, clients and superiors play in professionals' motivation to keep current (p. 56).

Matthias (1991) proposed a hybrid model between the "expectancy-valance" model advanced by Rubenson (1977), and the continuing education of health professionals model developed by Suter et al. (1981). The basic elements of the conceptual framework related to the professional work environment and competence included:

> 1. Continuing competence is a dynamic process, based on professionals' discipline, autonomy and accountability. Continuing competence is a constantly moving target, or a journey, rather than a destination.
>
> 2. The workplace setting is seen as the environment that identifies the potential learning needs for the professional at the conclusion of, or during the performance of, the service or task.
>
> 3. The quality of the task outcome is a function of the interaction of the professional's competence, the employer's degree of incorporating new technology assists in the workplace, the patient's or client's competence to understand the work and the role of the professional, and the degree of diffusion of new knowledge and technology.
>
> 4. The feedback from the workplace and the impact of new knowledge and technology are seen as positive motivating forces for the professional to participate in further learning (Matthias, 1991, p. 61).

The preceding points illustrate continuing competence is a complex, multi-facted phenomena operating at a number of levels. Matthias (1991) noted:

> ...the other part of the model (the workplace setting) with its continuing feed-back to the practising professionals, emphasizes the notion that professionals are a distinct group of learners among adults. The effect of the workplace feed-back (through peers, superiors, and clients) and the influence of new knowledge and technology are seen as additional forces which positively affect the likelihood of participation in further learning by the professional (p. 59).

Nowlen (1988) described the performance model in professional learning and change as being embedded in an understanding that even "as an individual matter, performance is the result of interacting social and personal influences" (p. 86).

Nowlen critiqued the more common update and competence models of continuing professional education as not adequately incorporating the realities of the work environments which professionals encounter. He viewed variables which influence professional performance as complex and interactive. These variables included: baseline knowledge and skills; the challenge of new roles; requisite skills in human relations; critical skills of mind; proficiency in self-managed learning; individual developmental progress, organizational developmental balance, the fit of the individual and organization to one another; skills in coping with life's surprises as well as its anticipated transitions; and understanding the influences of environments and cultures along with the skills to orchestrate them (Nowlen, 1988).

Willis and Dubin (1990) highlighted challenging work assignments which are complex and require professionals to combine previously acquired knowledge and skills with newly developed information to solve problems as an important professional work environment condition for maintaining competence. They also noted that open communication and collaboration among peers and with management "...serves as a powerful mechanism for maintaining and enhancing professional competence" (Willis and Dubin, 1990, p. 311).

Another professional work environment condition identified with facilitating competence includes flexible organizational structures and management policies that permit the reassignment of personnel and work responsibilities so a professional's current competencies are well used and new ones are developed through new and challenging work assignments (Willis and Dubin, 1990). Additionally, Farr and Middlebrooks (1990) argued that organizations need to demonstrate awareness of and involvement in an individual practitioner's own particular professional development goals and concerns.

The literature on change and the professional work environment indicates that effective policy and practice for professional competence, then, should incorporate a multi-faceted, complex process which requires understanding contextual factors of the professional work environment which affect engineering and earth science practice.

The Nature and Domains of Professional Learning

The terms education and learning are used interchangeably in education literature and practice (Houle, 1980). In facilitating effective learning experiences for professionals it has been suggested that it is important to understand learning "is wider than education; education is only one social institution in which learning occurs, albeit the only one specifically directed toward it" (Jarvis, 1992, p.10). A focus on performance-oriented, continuing professional development has also been much more closely associated with learning. Sanford (1989) indicated:

> Because professional competence involves much more than technical knowledge, however, our view of learning must become more dynamic. Learning must be seen as a continuing process of acquiring meaning and making sense of the world (p. 31).

Jarvis (1992) further advocated that:

> Learning, then, is the essence of everyday living and of conscious experience; it is the process of transforming that experience into knowledge, skills, attitudes, values, and beliefs. It is about the continuing process of making sense of everyday experience - and experience happens at the intersection of a conscious human life with time, space, society, and relationship (p. 11).

Viewed from this perspective, these authors have suggested learning transcends the domain of formal, structured learning experiences embodied in educational programming approaches to encompass the very essence and interpretation of experiences which occur in daily life (Jarvis, 1992).

Other authors have noted that training and education are delivery systems, while learning can be more broadly defined as the way in which "individuals or groups acquire, interpret, reorganize, change, or assimilate a related cluster of information, skills, and feelings" (Marsick and Watkins, 1990, p. 4). Professional learning has more recently been broadly defined by Baskett and Marsick (1992) as a "personal, emotional, and cognitive act, the results of which are unique to the individual, we all learn all of the time, but no two individuals learn exactly the same thing from a similar experience" (p.3).

Learning has been described as comprising a continuum ranging from formal learning, which relies highly on third-party, human agency (i.e., instruction) to influence the learning process, through to informal and incidental learning (Marsick and Watkins, 1990). Jarvis (1992) suggested learning "might be regarded as a response to an experience or even a response to an experience created through an action" (p. 70). He noted there are essentially nine possible responses to an experience which can be grouped into three overarching categories: nonlearning, nonreflective learning, and reflective learning (Jarvis, 1992). Marsick and Watkins (1990) discovered that up to 83% of the learning that occurs in organizations happens through informal and incidental means. They define informal learning as "predominantly experiential and non-institutional" while incidental learning "is unintentional, a by product of another activity" (p.7).

Mezirow (1981, 1991) advanced a theory of informal learning based on critical theory. He differentiated between three domains of learning which have been described as instrumental, dialogic, and self-reflective. Instrumental learning refers to task-oriented problem solving, dialogic learning refers to the way in which people arrive at understanding consensual norms in society, and self-reflective learning is the way in which we come to understand ourselves (Marsick, 1988; Mezirow, 1981).

Marsick (1988) interpreted Mezirow's (1981) work within the context of the professional work environment when she suggested instrumental learning is what commonly takes place when practitioners learn technical aspects of their practice better. Practitioners "identify a problem, formulate a hypothetical course of action, try it out, observe the effects and assess results" (Marsick, 1988, p. 191). Dialogic learning takes place when practitioners "learn about the culture of the organization or when they interpret policies, procedures, goals, and objectives" (Marsick, 1988, p. 191). Self-reflective learning is directed at self with its focus as a member of larger social units "in order to ask fundamental questions about one's identity and the need for self-change" (Marsick, 1988, p. 191). It has further been suggested that instrumental, dialogic, and self-reflective learning can not be easily separated (Marsick, 1988; Mezirow, 1981, 1991).

The foundations and maintenance of professional learning discourse, however, are deeply entrenched in formal educational programming (Belsheim, 1986; Cervero, 1988; Houle, 1980). Tradition has it that once an aspiring practitioner has made a choice to pursue a particular professional path, a prescribed path of formal preservice education will be pursued. Following completion of formal preservice, an inservice or induction process usually occurs, such as an residency, practicum, or internship (Houle, Cybert, and Boggs, 1987). Once full professional status has been achieved, a myriad of formal continuing education interventions are generally prescribed as the way to keep up-to-date with changing practice standards and methodologies (Nowlen, 1988).

Preservice Professional Education

Most professional preservice preparation, particularly for "traditional" professions, such as medicine, law, and engineering, occurs at the university level (Houle, et al., 1987). The requirement of university level preparation is, in part, an indicator of the highly valued social contract implied in the nature and purpose of a profession (Becker, 1962; Cervero, 1988). Professional schools are usually the exclusive entry point for a self-governing profession. Houle, et al. (1987) indicated that Blauch has characterized the role of professional schools as:

> As those schools have developed, they have come to perform several significant functions of which the most obvious are: (a) to recruit for professional training sufficient numbers of capable persons to staff the professions; (b) to develop those recruits to an approved scientific, technical, and professional competence; (c) to graduate those who demonstrate the knowledge, technical abilities, personal character, and social outlook required for the practice of the professions; and (d) to engage in research and development and thus contribute to professional knowledge and practice (p. 88).

Professional education has three basic dimensions. The first includes general education composed of the skills, values, and knowledge deemed to be "...basic to understanding national and world cultures, communicating effectively, appreciating civilization's and nature's esthetics and becoming an educated person" (Houle, et al., 1987, p. 88).

The second dimension of professional education is specialty education. This provides the foundational content information required for practice. This information does not teach a neophyte how to practice one's profession, but it provides the necessary background to comprehend the substance of each learned profession (Houle, et al, 1987). In engineering, examples of such subject matter might include work in advanced mathematics, thermodynamic theory, hydrology, etc.

A third dimension of professional education encompasses the professional courses students complete in order to learn professional skills. These include topics concerned with professional ethics, practice philosophy, and the standards of conduct which govern a professional's relationship with clients, society, and colleagues. A related element of this third dimension in preservice education includes learning the "how-to" practices which characterize accepted forms of practice (Houle, et al., 1987).

In addition to the formal curriculum of content in preservice education are the more subtle elements of professional education which are often described as comprising the "hidden curricuium" (Postman and Weigngartner, 1971). Through a process of professional socialization, also known as anticipatory socialization (Bush and Simmons, 1981), neophyte practitioners receive exposure to practice value sets. Becker and Carper (1956) noted there were four major elements of work identification characterized by the process of professional socialization of a referent group that included mechanical engineering graduate students. These four major elements included: (1) occupational title and associated ideologies; (2) commitment to task; (3) commitment to particular organizations or institutional positions; and (4) significance for one's position in the larger society (Becker and Carper, 1956).

It is this process of professional socialization that is intended to facilitate a strong sense of professional mission. This concept of professionalism is considered to be a significant motivating factor in a practitioner's disposition towards change (Fox, et al., 1989) and in encouraging a desire for continued inquiry and performance throughout a professional career (Houle, 1980). Professionalism, a product of professional school socialization, has in fact been reported as a permanent, discrete, and powerful agent for change (Fox, et al., 1989). In their study of physicians, Fox and his associates reported "purely professional motivations as driving the largest fractions of changes they made" (p. 9).

The extent to which professionals transition through a variety of roles throughout a career and the effect this has on their disposition towards learning and change is poorly understood. This is largely because the field of study is emerging and is still in its infancy (Fox, et al, 1989). While much has been advanced about role acquisition, role conflict, and role transition, very little appears to be known about how recurring discontinuous change affects professionals (Bush and Simmons, 1981; Handy, 1989,1994). A major concern about professional socialization, recurring discontinuity, and competence relates to attitudes about learning. One of the under emphasized values of socialization is a zest for learning (Houle, 1980; Matthias, 1991). In fact it has been suggested this lack of zest for learning has been a product of the modern educational system (Drucker, 1993; Houle, et al., 1987). The fact that an explicit ethos of ongoing, career learning has not been more prominent in preservice socialization has profound implications for contemporary professional practice which is characterized by recurring discontinuity and transformation (Handy, 1989; Mezirow, 1991).

Socialization can, therefore, be viewed as a developmental process which does not end at preservice graduation, but as an active process that should be encouraged throughout a career (Moore, 1969). Approaches to curriculum design such as inquiry-based learning, experiential learning, and problem-based learning, combined with a culture in the professional school of discovery and experimentation, have been suggested as more conducive to instilling these approaches to professional practice (Kolb, 1984; Margetson, 1994).

Continuing Professional Education

The rapid evolution of continuing professional education is a relatively recent one and has developed primarily from two schools of thought (Cervero, 1988). In the first school, leaders in some professions have always seen ongoing learning as a central tenant of professional practice. Of this first school, Houle, et al. (1987) noted:

> To many pioneers, it seemed self-evident that advanced technical knowledge could not be acquired in a few years of schooling at the beginning of adulthood; practical necessities would require any successful physician, attorney, engineer, or other practitioner to keep on learning in order to solve the problems that appeared daily. Moreover, such pioneers, being activists, assumed that everybody else, like themselves, would be avid to learn anything new that would help them (p. 89).

The other major school has essentially viewed continuing professional education as a formal programmatic means of encouraging the ongoing development of practitioners and by extension, ensuring professional competence. Completion of continuing education offerings have in fact often been tied to the privileges which have granted as a condition of licensing (Cervero, 1988; Matthias, 1991).

Continuing professional education has exploded into a huge and rapidly growing enterprise (Cervero, 1988). Notwithstanding this impressive growth, the efficacy of continuing professional education has become the focus of increased scrutiny and criticism (Belsheim, 1986; Day and Baskett, 1982; Nowlen; 1988). For example, Houle (1980) proposed a model of continuing learning which incorporated the concepts of inquiry, performance, and instruction as three primary modes of professional learning. Indeed, Houle, et al. (1987) commented that most CPE programs focus primarily on instruction, are removed from the realities of practice, and do little to reinforce the knowledge and skills learned in the CPE program in a way that they can be effectively transferred into practice.

According to Gosnell (1984), quoted in Cervero, Rottet, and Dimmock (1986), in a review of 17 nursing education programs the results were "inconclusive as to the effect of continuing education on particular behavioral changes or ultimate outcomes" (p.10). Rockhill (1983) suggested one reason for the reliance on mandatory continuing education has been a widely held belief that education equals competence and competence equals accountability. Cervero (1985) proposed that the factors considered in analyzing the effectiveness of continuing professional education be expanded, and Nowlen (1988) has been one of the most vocal critics of continuing professional education. He has argued that:

> Continuing education is, at present, heavily didactic and is directed toward keeping professionals up-to-date. This overarching and ambiguous aim provides continuing professional education with conceptual utility without wedding it to performance outcomes (Nowlen, 1988, p. 21).

Raising similar concerns to those expressed by Nowlen, Cervero (1988) also noted of CPE that:

> Furthermore, these simple activities are expected to improve the performance of professionals whose practices are full of complexities, uncertainty, and conflicting value judgments. Given these conditions, the great concern in the professions with the quality of continuing education should not be surprising (p. 3).

A review of continuing professional education's primary goal prompts cause for concern that it is not consistently achieved (Cervero, 1988; Cervero and Rottet, 1984). Houle, et al. (1987) suggested the "ultimate goal of all continuing professional education is the improvement of the ongoing performance of practitioners" (p. 91). Matthias (1991) has argued that many authors vehemently opposed to mandatory continuing education have stated that "attendance does not equate education, learning takes place in any setting, and adults' most rewarding experiences are job-related and involve problem solving" (p.41).

The conceptual model which most continuing professional education has been founded upon within the programming tradition is known as updating (Dubin, 1990; Nowlen, 1988). The update model focuses primarily on the transfer of static, codified information and is predicated on a conception of knowledge which is highly positivistic (Schön, 1983). That is, knowledge which is certain, hierarchical, and determinate. Nowlen (1988) suggested:

> Updates view professionals as if they were at the passive end of a series of mediatory steps, each at increasing distance from the world of "real" knowledge... The update is still tied to positivism that was well established early in the century, and that still influences the way professionals view themselves (p. 25).

The difficulty suggested with the update model is that it is largely disconnected from the realities of modern professional practice (Cervero, 1992; Day and Baskett, 1982; Schön, 1983, 1987). Updating has been advocated as useful for remediating some of the foundational knowledge which becomes outdated as advances in basic and applied research reveal more effective technical approaches and methods for practice (Dubin, 1990). Updating, manifested through the education model, appears to do little to address the messy, unique, ambiguous issues professionals must address in a dynamic professional work environment (Belsheim, 1986; Nowlen, 1988, Schön, 1983). In fact, affecting changes to deeply rooted practice behaviors appears to be a long, involved process (Baskett and Marsick, 1992; Cervero, 1992; Fox, et al., 1989, Jarvis, 1994).

Scalan and Darkenwald (1984) identified several deterrents to participation in continuing education. Among these included the practitioner's perception of returning to the role of learner, cost of programs, family constraints, perceived benefit from program participation, perceived quality of the program, and work constraints. Cervero (1988) also considered professionals' reasons and deterrents to participation; their zest for learning; their age and career stages; the nature of the practice setting; and the extent to which they were required to participate in continuing education as important factors influencing motivation for participation in continuing education.

In a review of the stated reasons why physicians attend traditional continuing professional education programs, Richards and Cohen (1980) discovered that a physician's:

> ...inner standards of achievement and need to validate their information and practices are seen as more important reasons for CME attendance than are mandatory CME regulations and change of pace (p. 479).

It may be a reasonable assumption that professional engineers and earth scientists also perceive inner standards of achievement and the need to validate practice as more important reasons for attending formal continuing professional development than for a mandatory requirement imposed by an external agent.

A review of the literature on continuing professional education suggests that many of the problems associated with the field's evolution to date have been identified but not resolved (Cervero, 1988; Cervero and Rottet, 1984; Day and Baskett, 1982; Nowlen, 1988). More work is required to identify the appropriate role of continuing professional education as a facilitator of professional competence. As Mattihias (1991) noted:

> Mandatory continuing education has long been associated with competence in many professions, however, among the "agents for change" in professional behaviour (at least among physicians and engineers), continuing education is ranked second to reading of periodicals and scientific journals (p. 41).

Indeed the development and maintenance of competence is a convoluted, complex process (Sanford, 1989). Conceptualizing continuing professional education as a singular variable for affecting behavioral changes in professional practice oversimplifies this complex, multi-facted process (Cervero, Rottett, and Dimmock, 1986). This critique does not diminish the role of continuing professional education in developing and maintaining competence. Formal continuing professional education may effectively be seen as only one agent in the range of activities used to develop and maintain professional competence (Baskett and Marsick, 1992; Marsick and Watkins, 1990; Matthias, 1991).

Informal and Incidental Learning

Informal and incidental learning are based on the supposition that learning from experience and context are powerful sources of knowing. Marsick and Watkins (1990) noted that incidental learning is sometimes identified as a subset of informal learning, with the distinction being that incidental learning is not intended and occurs as the byproduct of another activity. That is, it is learning which has not been premeditated or anticipated (Jarvis, 1994; Marsick and Watkins, 1990). Two forms of professional learning and knowing associated with informal and incidental learning which are examined in detail in this section are self-directed learning (Knowles, 1975; Tough, 1971) and reflective practice (Schön, 1983, 1987).

Informal learning as a form of continuing professional development has been identified in professional engineering practice (Cervero, et al., 1986; Jones and LeBold, 1987). Challenging work assignments, permission to have work assignments enlarged, and informal contact with coworkers were reported as powerful forms of continuing development (Jones and LeBold, 1987). Consulting a variety of internal and external resources were seen as important means of keeping up-to-date technically by engineers employed in companies (Cervero, et al., 1986; Jones and LeBold, 1987).

The intellectual traditions for informal and incidental learning can be found in the work of Lindemann (1926), Dewey (1938), Knowles (1950), Lewin (1951), and Argyris and Schön (1974). Informal and incidental learning involves experiences where a professional does not draw upon external resources. The learning, in effect, occurs within and among individual practitioners (Fox, 1991).

It has been suggested by Schön (1983) that awareness of the sources of professional knowledge is an important aspect in understanding professional learning and change. Discourse on professional learning has emerged around two major schools. One school of thought is founded in a highly positivistic conception of knowledge. Schön (1983) and Nowlen (1988), vehement critics of this approach, suggest that proponents of this school maintain the legitimate source of professional knowledge is through rigorous experimentation. Knowledge is then generated in the form of generalizable statements about the nature of the world.

The other school maintains that all knowledge, including empirically generated knowledge, is socially constructed at some level (Cervero, 1992; Nowlen; 1988; Schön, 1983, 1987). It has been suggested that viewing the source of professional knowledge as socially constructed has important implications for continuing professional development. Nowlen (1988) submitted:

> ...to reject the positivist view of knowledge and of the way professionals "know" is to shift continuing education's fundamental orientation from the professional as passive consumer to the professional as an active source of knowledge about the critical elements of professional performance (p. 28).

One result of the recent shift in the discourse about professional knowledge has been a better understanding about the source, nature, and complexity of professional knowledge (Baskett and Marsick, 1992). The professional as an important source of legitimate professional knowledge was largely popularized as a result of Schön's (1983, 1987) work on the reflective practitioner. This debate was advanced through a growing awareness that problems professionals had been encountering in practice were not sufficiently addressable within the dominant positivist view of knowledge (Nowlen, 1988). Schön (1983) submitted the nature of complex, ambiguous, and unique problems encountered in professional practice presented one useful set of criteria for a critique about the source of professional knowledge. In fact, Schön (1983) noted:

> Increasingly we have become aware of the importance to actual practice of phenomena - complexity, uncertainty, instability, uniqueness, and value-conflict - which do not fit the model of Technical Rationality...From the perspective of Technical Rationality, professional practice is a process of problem solving. Problems of choice or decision are solved through the selection, from available means, of the one best suited to established ends. But with this emphasis on problem solving, we ignore problem setting, the process by which we define the decision to be made, the ends to be achieved, the means which may be chosen (p. 39-40).

A fundamental challenge for educational practice in this frame of professional knowledge involves building linkages for incorporating knowledge disseminated through educational programming with knowledge developed in practice. In placing the role of educational programming in context with professional knowledge, Cervero (1992) suggested the goal of professional practice is wise action. He noted knowledge acquired from practice is necessary to achieve wise action, given the action orientation of practice is an:

> ...attempt to put matters right rather than uncover the truth. Thus practice is a normative, not a descriptive, enterprise. If practice is normative, then wisdom must be seen as socially constructed...Wise action means making the best judgement in a specific context and for a specified set of ethical beliefs (p. 92).

Wise action is achieved through the utilization of two types of knowledge: declarative knowledge and procedural knowledge, or knowledge what and knowledge how (Cervero, 1988, 1992).

Declarative knowledge, most often associated with university preservice education, provides a foundation upon which procedural knowledge can be

(Cervero, 1992; Jarvis, 1994). Declarative knowledge is an antecedent for procedural knowledge, but wise action in professional practice is not possible without procedural knowledge (Cervero, 1992). This may be one reason for explaining why many practitioners commonly criticize their university experience as being too theoretical. Practitioners come to realize that it is procedural knowledge, developed through experience and exposure to new "surprises" in practice, which is most useful in achieving a high level of competent professional performance (Cervero, 1992; Schön, 1983; 1987).

Jarvis (1994) noted a potential impediment for professional learning and change arises out of reliance on procedural knowledge because "...they know it works, it is necessarily conservative in nature - why should actors change their behavior when the know what they are doing works?" (p. 32). This finding about the difficulty in affecting change due to the conservative nature of procedural knowledge was also cited in Fox, et al.'s (1989) work:

> Changing their clinical performance is difficult except when they are in favor of change, have readily available means and ends, and some control over the process (p. 551).

With respect to the relationship between declarative and procedural knowledge, Belsheim (1986) suggested organizing programming within a social change or problem-based orientation. The purpose of such an approach would be to more actively involve practitioners in determining a learning agenda that more closely mirrored the needs and realities of practice (Belsheim, 1986; Nowlen, 1988).

Self-Directed Learning. Self-directed learning is the most commonly recognized form of informal learning in adult education theory and practice. Knowles (1975) and Tough (1971) are credited with much of the seminal work in the area. Self-directed learning is based on the concept that adults are capable of determining what they need to learn, what resources they require to affect learning, and what results are anticipated (Langenbach, 1993). Richards (1986) noted that:

> Self-directed learning theory has been shaped by humanistic psychologists like Carl Rogers, who states that much more significant and lasting learning can take place when the learning is integrated with work or is acquired through active involvement. Learning is facilitated when learners define their own problems, discover their own resources, decide their own course of action and recognize the consequences of the decisions. The most lasting, pervasive result of self-directed learning, Rogers contends, is the learner's growing confidence in his or her ability to learn independently (p. 1).

Self-directed learning has been an intuitively appealing model, particularly in North America (Brookfield, 1993). There have been, however, methodological problems with the universality of self-directed learning. As Brookfield (1981) and Tennant (1986) noted, those who are disposed to self-directed learning generally have relatively higher levels of education than the norm and within the context of humanistic psychology, are generally more capable of achieving meta-needs leading to self-actualization.

Given the levels of education which professional engineers and earth scientists attain prior to induction into professional practice, it would seem the universality critique Brookfield (1981) and Tennant (1986) have raised should not greatly affect self-directed learning's application for professionals, unless traditional preservice education influences professionals' attitudes towards how they should learn in practice (Fox, 1990). For many professionals, self-directed learning starts with something new they have read or heard about, as well as starting and ending with a client (Jennett and Swanson, 1994). Self-directed learning appeals to many professionals for it provides a frame for learning which enables them to solve specific practice related problems, usually within their own practice settings (Richards, 1986).

It has also been argued recently that self-directed learning is a much more complicated process than which was initially envisioned (Brookfield, 1993; Garrison, 1992). The focus of many models of self-directed learning has been on the individual learner, often to the detriment of a recognition that there is also an important social and collective dimension in self-directed learning. Group learning as a powerful form of informal and incidental learning was noted by Watkins and Marsick (1992):

> ...Tough - as with most self-directed learning theorists - speaks primarily about individually initiated learning. Informal and incidental learning has a collective dimension to it, even though individuals are the prime movers in whatever learning happens (p. 292).

It has further been suggested that self-directed learning and critical thinking are more closely linked than initially envisioned. Greater understanding of learner responsibility and control is required before the power of self-directed learning can be fully appreciated for its role in facilitating effective continuing professional development. (Garrison, 1992, in press). Garrison (1992) noted that:

> Taking responsibility for learning is a core element of critical thinking and is a precondition to understanding and knowledge development. Sharing control through discourse provides the learner with guidance and a way of confirming meaning/knowledge (p. 147).

This concept of an integrated approach introduces a level of complexity which suggests that self-direction and critical thinking are intimately connected, with an important cognitive dimension, and with a learning environment which is necessarily social despite the fact that the learner might engage in individual learning pursuits (Garrison, in press; Marsick, 1988).

Garrison (in press) has proposed a conceptual framework for understanding learning. His self-regulated learning framework attempts to broaden the discourse in the area of self-direction by incorporating and integrating a range of psychological and sociological dimensions. He notes:

> The psychological dimension is composed of motivational and cognitive components. The motivational and cognitive components have been referred to as the "will" and "skill" issues. The psychological dimension recognizes perceived cognitive abilities and the importance of learners to assume responsibility for monitoring their motivational and cognitive strategies. On the other hand, the sociological dimension is concerned with goal setting and management of learning tasks. The fundamental issue with this dimension is the control of learning goals and methods. The sociological dimension is associated with transactional and andragogical issues; that is, the organization and implementation of the education experience.

Garrison (in press) suggests that choice motivation, (through a triggering event that causes a learner to choose certain learning goals); valence (as the attraction to particular learning goals); expectancy (as the belief that a desired learning outcome can be achieved); anticipated control (as the perception of expectancy of success and perceived decision making control); and task motivation (in the persistence demonstrated in sustaining intentional effort) are critical psychological dimensions requiring consideration in self-regulated learning.

Self-regulated learning is important for continuing professional development in that it incorporates the dimensions of critical reflection that are essential for being aware of basic assumptions which may no longer be valid as a result of discontinuous, structural change (Brookfield, 1993). Brookfield (1985) noted in his revised definition of self-directed learning:

> ...a fully adult form of self-directed learning is evident when the techniques of self-direction are married to a critical scrutiny of existing values, beliefs and social forms (p. 63).

It would appear, then, that effective informal learning which is embodied within self-direction must incorporate dimensions of critical reflection. This is so that professionals learn to become aware of potentially self-defeating assumptions which may underlie practice, especially as established standards of acceptable practice continue to change in light of rapid sociopolitical, technological, and economic changes in the profesional work environment (Brookfield, 1993; Mezirow, 1981, 1991).

Self-directed learning has been researched in professional engineering practice (Jones and LeBold, 1987; Rymell and Horton, 1981). An indepth study of 30 engineers using Tough's (1970) methodology revealed that 371 self-directed learning projects had been initiated by the sample of engineers in the areas of vocational or job-related activities, hobbies and recreation, current events, home and family life, personal development, academic and general education, and religious activities (Rymell and Horton, 1981). Engineers cited the five most common problems in organizing learning projects as: deciding about how much time to spend on a project and when to spend it; obtaining learning resources; making decisions about which activities were necessary to gain the desired knowledge and skills; deciding what knowledge or skills they wanted to learn; and applying the knowledge (Rymell and Horton, 1981).

As an alternative to traditional, program-based continuing professional education, the Royal College of Physicians and Surgeons of Canada recently piloted a Maintenance of Competence (MOCOMP) program (Campbell, et al., 1995). The MOCOMP program was established to facilitate the planning and tracking of informal, self-directed learning which transcends formal mandatory continuing education. The tool used to capture information about self-directed learning was developed in format of a small, personal diary. One aim of the MOCOMP program is to enhance physicians' autodidactic competence in the area of being able to reflect upon, identify, and act upon their own practice-based learning requirements. Some methodological and logistical problems have been reported in identifying when learning occurs, when it should be recorded, and how it should be recorded. Twenty percent of respondents in the pilot reported not using the diary to capture their self-directed learning (Campbell, et al., 1995). Perceptions of excessive bureaucracy, forgetfulness, and insufficient priority in relation to other activities were cited as major reasons for not using the diaries. It has been noted that the "MOCOMP program is a difficult option in comparison with other CME programs. It places demands on the physician to develop a plan of continuing professional development that encourages reflective learning" (p. 84).

Reflective Practice. Reflection as a form of informal learning can be conceived and understood from a number of perspectives. It can be seen as a process which leads to thoughtful, mediated action, involving the implementation into practice of findings and theoretical formulations from a field of practice (Schön, 1983). Furthermore, reflection can be conceived as deliberation and choice among competing versions of good practice, as well as the reorganization or reconstruction of experience (Grimmett, Mackinnon, Erickson, and Riecken, 1990).

Reflection as described by Schön (1983), is an informal way of learning, in that knowledge, a product of learning, "...is inherent instead, in the action; it is based, in part, on the past experiences of the practitioner interacting with a particular situation" (Richardson, 1990). This type of learning would be referred to in Schön's (1983, 1987) typology as reflection-in-action and reflection-on-action. The former occurs when a practitioner is surprised during the course of an intervention, makes an adjustment to the practice pattern to accommodate the immediate case. Fox (1991) suggested reflection-in-action has been considered provocative for it seems "...to encompass an area of learning that is free from the direct influence of formal or informal resources" (p. 165). The reflective practice model is appealing for learning among professional engineers and earth scientists, for it combines the science of a profession (the zone of mastery) with the art of a profession (a zone characterized by uniqueness, conflict, and ambiguity) (Crandall, 1993). According to Schön, "as professionals solve problems they work through five stages: (1) knowing-in-action, (2) surprise; (3) reflection-in-action, (4) experimentation, and (5) reflection-on-action" (Crandall, 1993, p.87).

A higher level of reflection of interest in contemporary professional practice is critical reflection. In making the distinction between reflection and critical reflection, Stephen Brookfield (personal communications, February 16, 1995) stated one of the ways that one may ascertain the difference between reflection and critical reflection is that within a frame of critical reflectivity, a practitioner becomes aware of potentially self-destructive assumptions. Marsick (1988) further explained this by indicating the characteristics of critically reflective practitioners in the workplace setting:

> Critically reflective learners are continually sensitive to why things are being done in a certain way, the values these reflect, the discrepancies that exist between what is being said and what is being done, and the way in which forces below the surface in the organization shape actions and outcomes...They will determine whether or not they see the problem and proposed solution in the same way, probe the organizational context to ferret out facets of the culture that influence action, and attempt to understand how suggested solutions fit with their own image of themselves (p. 191-192).

The research on reflection is important for continuing professional development because it highlights the nature of practitioner-valued knowledge creation in professional practice. It also illustrates the importance of critical reflection in times of discontinuous, structural change in the professional work environment (Cervero, 1992; Fox, et al., 1989).

Proficiency, Competence, and Performance

Proficiency, competence, and performance are interrelated concepts central to understanding effective professional practice. Demands for increased accountability, through the demonstration of wise professional action, has become a matter concern to many stakeholders responsible for recertification and relicensure (Norcini & Shea, 1993). The desire to maintain professionalism, a basic dimension which involves the ongoing demonstration of performance, is a primary motivator for professionals to develop strategies to continue learning as the nature of their professional work environments change (Fox, et al., 1989).

The concept of proficiency has been largely based on the work of Knox (1990) who suggested proficiency could be thought of as a combination of knowledge, attitude, and skill that constitutes the capability of a professional to perform satisfactorily if given the opportunity. Central to Knox's proficiency construct is the idea that professionals are given the opportunity to demonstrate proficiency. The conditions for demonstrating proficiency, many which are factors of the professional work environment, can also be interpreted as antecedents for achieving professional performance (Nowlen, 1988).

The nature of interaction between practitioners and the context of their practice, as mitigated by the professional work environment, is a central distinction in separating the concept of competence from that of performance (Nowlen, 1988). Competence focuses heavily on individuals' capabilities, rather than on individuals' ability to execute their capabilities (Knox, 1990; Nowlen, 1988). Performance takes the concept of proficiency and competence beyond the realm of the individual practitioner and assumes the context and a practitioner's interaction with the context (professional work environment) affects performance. Through this interaction a complex cognitive and psychosocial process occurs in which professionals attempt to employ their competencies to affect desired practice outcomes (Nowlen, 1988; Ross and Nisbett, 1991).

Within the broader concept of performance, competence is not viewed as static and measurable solely by a universal set of standards, or demonstrable behaviors. What may be considered suitable competence for performance in one practice situation may not be suitable in another practice setting. Therefore, contextual factors underlying the professional work environment are central to the distinction between competence and performance (Nowlen, 1988). Informal and incidental learning strategies are used by professionals in practice as a strategy for gaining the additional procedural knowledge and practice skills required for demonstrating performance (Cervero, 1992; Knox, 1990; Marsick and Watkins, 1990; Nowlen, 1988).

Sanford (1989) has suggested that defining, measuring, and assuring professional competence is one of the most pressing contemporary issues for stakeholders. Houle (1983) indicated the overriding concern for an emerging era in continuing professional education would be a practitioner's quality of performance. Houle (1983) noted quality of performance has not been central to past continuing education efforts organized through the programming model:

> Judgements about the quality of performance are already widely used in administrative review and peer appraisal systems. They are not general,

> however, but system-specific and they have seldom been considered as outcomes of continuing education (p. 261).

Stakeholder concern for more emphasis on professional performance contributes to a shift in conceiving the processes of continuing professional development as th which are much broader than provided by much continuing professional education (Day and Baskett, 1982).

Fossum and Arvey (1990) argued that although loss of competence occurs at the individual level, the antecedents and mediators of competence loss tend to largely be marketplace and organizationally oriented. These authors found that changes "...in the marketplace and ineffective responses by organizations can lead to a professional's current skills being rendered obsolete" (Willis and Dubin, 1990, p. 307). Nevertheless, Willis and Dubin (1990) highlighted that an understanding of both micro and macro level factors related to the professional work environment are important to an effective understanding of the causes of competence loss and performance impedance.

Miller (1990) suggested an enriched work environment where by practitioners have the ability to actively use professional knowledge and skills is critical for maintaining competence. He noted (1990):

> ... in response to business needs some organizations leave significant numbers of professionals on technical byways while others pursue new technology. Under these circumstances new learning is impeded and decreased competence is assured. Any work environment that impedes individual growth invites deterioration (p. 233).

Miller (1990) prescribed an approach to performance-oriented, continuing professional development in which work assignments are designed so they "...stretch the professional and cause the need for continued learning and growth in capability" (p. 235).

Willis and Dubin (1990) also argued competence should not necessarily be viewed as a linear, static construct. They suggested that professionals develop clusters, or domains, of competence at various levels. For example, because "...of a supportive work environment or deliberate updating activities, a midcareer professional may remain competent in some dimensions but less competent in others" (Willis and Dubin, 1990, p. 309).

Three main strategies have been advocated for maintaining competent professional performance. The first strategy involves a focus on features in the professional work environment that foster the maintenance of competence and the demonstration of performance. The second strategy emphasizes training, through formal programming, in skill, attitude, and knowledge areas which are deficient. The third strategy involves updating and renewal through self-directed learning (Willis and Dubin, 1990).

Summary

This section involved a review and discussion of literature in areas related to the nature of change and the professional work environment, domains of professional learning and knowing, and concepts related to proficiency, competence, and performance.

The review revealed that professionals face a complex and volatile professional work environment in which a variety of learning occurs which transcends formal preservice and continuing education. This learning is generally geared towards the performance needs of practitioners in practice settings. The review also revealed relatively little primary research had been done to identify the range of learning activities professional engineers and earth scientists use to develop and maintain competent professional performance in relation to a changing work environment. Finally, there was also a great deal of emerging interest linking the range of continuing learning in professional practice to the demonstration of competent professional performance.

The next chapter presents the research methodology, research instrument, and data collection process used for this study. Organization of the data and the process used to conduct the analyses is also discussed.

CHAPTER III

RESEARCH METHODOLOGY

The research methodology for this study was chosen to highlight the learning activities used by professional members of the Association of Professional Engineers, Geologists, and Geophysicists of Alberta (APEGGA) to maintain competent professional performance. A descriptive survey was used to gather data on the nature of learning activities used in professional practice, facilitators and inhibitors of effective continuing professional development, and factors related to the professional work environment which influence learning and performance. This chapter highlights the methodology for conducting the study. The overall design of the study is described, followed by a discussion of the research instrument. The methods of data collection, ethical considerations, as well as the population and sample are then discussed. The strategy for data analysis is presented last.

The Descriptive Survey Method

The purpose of this study was to identify the activities professional engineers and earth scientists in Alberta use to maintain competent professional performance. A secondary purpose of the study was to assess the transferability of theoretical perspectives and research findings of recent studies about professional learning and change in other professions and contexts. Under central consideration was the concept that professionals use a continuum of formal, informal, and incidental learning to develop and maintain competent professional performance (Cervero, et al., 1986; Jones and LeBold, 1987; Marsick and Watkins 1990). Also under consideration was the nature of change, its affect on the professional work environment (Fox, et al., 1989) and the sources of knowledge valued in professional practice (Schon, 1983, 1987).

The descriptive survey method was used as the researcher was attempting to collect data to describe a particular phenomenon in a definable context at a particular point in time (Leedy, 1993). Exploratory research on professional learning and change had previously been conducted by other researchers and provided an excellent foundation for a descriptive study of Alberta professional engineers and earth scientists (Cervero, et al., 1986; Fox, et al., 1989; Jones and LeBold, 1987). Therefore, the need to further explore relationships between findings in the previous research and the present practice of professional engineers and earth scientists in Alberta was also of interest in this study. The survey method afforded a great deal of flexibility in capturing data that could be drawn upon to glean important insights into particular phenomena, in a way that accounts for time and financial considerations which impact the feasibility of a study (Borg and Gall, 1989).

The Data Collection Instrument

The research tool (Appendix A) for this study was developed using items from related studies published in the public domain and by ideas gathered from a review of other questionnaires (APEGGA, 1981, November; Cervero, et al., 1986; Hanson and

DeMuth, 1991, 1992; Jones and LeBold, 1987). The research instrument was 13 pages in length and was organized into four sections: professional learner characteristics, the professional practice environment, demographics and current practice, and open-ended opinions and viewpoints on continuing professional development.

Research Instrument - Sections I and II

Both quantitative and qualitative data were collected through a combination of closed and open ended questions. The closed ended questions related to 185 discrete variables. Five of the 29 questions required a closed ended response with a comment space for respondents to offer open ended, explanatory comments. A four-point Likert type scale with a continuous variable distribution was used for some of the closed questions. For Questions 2, 5, and 6 in the questionnaire and fifth choice was available as *Does Not Apply*. Other closed questions, or components of questions, required a binary response (yes or no) or a single choice response. Choosing the binary response or single choice option was done by requesting respondents make an X mark in a box for variables which corresponded to their choices. The final three questions of the research instrument were open-ended and provided a forum for unstructured comments and suggestions for information that would not be gathered without prompting in the closed ended questions.

Question 1 of the research instrument was used to collect data about the reasons new information was sought in professional practice. This question was constructed as multiple response with seven discrete choices and an eighth open ended category for reasons that were not otherwise identified. The purpose of this question was to establish a baseline of motivating reasons that practitioners reported for seeking out new information.

Question 2 comprised ten discrete elements of the professional work environment. A four-point Likert type scale, ranging from 1 (*not important*) to 4 (*very important*) was used to rank elements in the work environment considered for their importance in enabling practitioners to conduct their work effectively. A fifth choice was presented for each variable in this question. A 5 (*does not apply*) option was added so that questionnaire items which did not apply to a respondent could be explicitly identified for the researcher by respondents. This process allowed the research to later isolate items which did not apply for some respondents from the analysis of the continuous variables. In this sense, adding a *does not apply* anchor was done to improve the integrity of the data for each of the items. This is because each of the variables were designed for continuous variable analysis. That is, if an item applied then a respondent was asked to rate the degree of importance if the item applied to a respondent's individual situation. If an item did not apply it was important to know this explicitly rather than have a respondent choose an anchor on the scale which might not have been an accurate representation of their response, but which enabled them to complete an item so that they could move onto the next one. The same strategy was used in the design for the variables contained in Questions 5 and 6 of the questionaire. These were the questions about activities used to develop and maintain professional competence. They are discussed in detail later in this section.

The elements examined in Question 2 included the current availability of equipment and facitilies; support from technical and non-technical personnel; access to new technical information; sufficient time to communicate internally and externally with colleagues; sufficient time to attend professional development activities; ongoing investment in company sponsored research and development; and career guidance. An eleventh open-ended *other* category was incorporated into the question to invite responses that might have otherwise been missed.

Question 3 was a multiple response question that was used to identify past formal continuing professional development activities the respondents had undertaken. Ten discrete content area categories and an eleventh open-ended one were used to identify a historical baseline of program-based, formal professional development in engineering and earth science practice undertaken by respondents.

Question 4 restated the same content area categories that had been listed in question three. The purpose of this question was to solicit responses from the sample in content areas where there was a perceived need for assistance in learning. A four point Likert type scale, ranging from 1 (*no need*) to 4 (*high need*), was used in the question which asked respondents to rate their need for structured approaches to learning in the ten content areas with an eleventh *Other* choice. Structured approaches to learning was defined for the respondents in the list of definitions (Appendix A) which accompanied the research instrument. For the purposes of this study, structured approaches were interpreted as meaning either structured assistance through formal programming, or informal assistance through the identification of learning resources which could be employed in self-directed learning activities.

Question 5 was a question of central interest in this study. This question identified 28 discrete formal and informal learning activities, with an *Other* category also provided, which professional engineers and earth scientists were thought to use in developing and maintaining professional competence. Respondents were asked to identify the importance of each variable for maintaining technical competence using a four point Likert type scale, ranging from 1 (*not important*) to 4 (*very important*). As discussed earlier in this section, a fifth *does not apply* option was integrated into the question so respondents could explicitly identify activities that did not apply to their individual situation. Variables for this question were primarily developed from prior work done in the United States in the 1980s by Cervero et al. (1986) and Jones and LeBold (1987).

Question 6 was, in part, a restatement of selected variables listed in question five. The focus of this question, however, involved an examination of activities used to develop and maintain managerial competence. This question contained 13 discrete variables as well as an *other* open-ended response. The question also used the same four-point ranking scale used in Question 5, which ranged from 1 (*not important*) to 4 (*very important*). The question was a branch question, meaning that it was to be completed only by respondents who worked in a supervisory or managerial role at the time that they were completing the questionnaire.

Question 7 was used to identify influences on participation in company-sponsored formal continuing professional development. This question listed five discrete responses. These included the degree to which company-sponsored, formal continuing professional development assisted the respondent directly in his or her work; was expected or required by a supervisor or department; led to career advancement; and the degree to which it created opportunities to get away from work and learn what other colleagues were doing. Responses were ranked using a four point Likert type scale, which ranged from 1 (*not important*)to 4 (*very important*).

Question 8 listed facilitators and barriers to the participation of professional engineers and earth scientists in formal continuing professional development. This question identified 23 discrete variables and one open-ended *Other* category. A majority of the variables in this question had been previously examined by Hanson and DeMurth (1991) in a 0.5 percent random sample of all licensed pharmacists in the United States. A four point Likert type scale was used to rank the importance of each of the factors. The scale ranged from 1 (*not important*) to 4 (*very important*).

Question 9 was used to inquire into the nature of formal recognition that could be offered for attending formal continuing professional development activities. The question was a forced choice question with six choices. Five of the choices were discrete and a sixth allowed for a respondent to specify another form of formal recognition that was not listed.

Question 10 required respondents to rank how effective they perceived nine common formal and informal learning activities. A tenth question was added for additional activities not explicitly identified within the context of the other nine discrete activities. A four-point Likert type scale, which ranged from 1 (*not effective*) to 4 (*very effective*), was used to rate the effectiveness of each activity.

Question 11 listed 24 discrete statements which were used to rate respondents' attitudes and perceptions of themselves as learners. A four-point scale, which ranged from 1 (*strongly disagree*) to 4 (*strongly agree*) was used to assess the extent to which the respondents agreed or disagreed with each of the statements. The statements were developed in large part, from earlier work that had been conducted by Livneh (1988). The purpose of this question was to ascertain the extent to which respondents perceived themselves as a learner.

The next section of the questionnaire focused on the Professional Practice Environment and consisted of eight questions. Question 12 of the survey was a two part question adapted from the 1981 descriptive survey that the Association of Professional Engineers, Geologists, and Geophysicists of Alberta had conducted into the continuing n activities and attitudes of members (APEGGA, 1981, November). The first part of the question was a forced choice (*yes*, *no*, *no opinion*) that asked whether the Government of Alberta should legislate mandatory continuing education activities for APEGGA professional members. The second part of the question was a branch question with the option of multiple responses. If a respondent answered part one of Question 12 as *no*, there were eight discrete choices, as well as an *Other* section, listing the rationale for why mandatory continuing education should not be legislated for APEGGA professional members. If a respondent answered *yes* to the first part of Question 12, there were five discrete reasons, as well as an *Other* section, where respondents could indicate why they thought mandatory continuing education should be legislated for APEGGA professional members.

There was a two fold purpose to the twelfth question. The first purpose was to compare attitudes about continuing education in the membership over the fifteen year period which had elapsed between the previous study and the current study. The second purpose was to generate information about mandatory continuing education which could be discussed within the context of Fox, et al.'s (1989) change typology.

Question 13 required a forced choice and was comprised of five discrete responses plus, a *no opinion* response and an *Other* response. The purpose of this question was to identify who the respondents perceived should be responsible for the maintenance of competence. A continuum of choices was presented which ranged from the employer being solely responsible for maintaining the competence of professional engineers and earth scientists through to the individual practitioner being solely responsible for maintaining competence.

Question 14 required respondents to rate their agreement with eight statements which represented commonly held attitudes towards continuing professional development, lifelong learning, and continuing competence. A four-point scale, which ranged from 1 (*strongly disagree*) to 4 (*strongly agree*) was used to assess the degree of respondents' agreement with each statement.

Questions 15 and 16 were two part questions developed by the researcher to solicit feedback to Schon's (1983, 1987) assertion that professional practitioners were experiencing an increase in complex problems to where there were not easy answers. Question 15 solicited a response to whether respondents had been experiencing an increase in complex engineering and earth science problems in their work that have no easy solutions. Question 16 asked respondents to list the number of times in the last three months where they had experienced a need for information, knowledge, or skills that could not be readily met. Six discrete categories were provided for respondents which ranged from (*1-3 times*) to (*more than 15 times*). Both questions fifteen and sixteen had a second part which invited explanatory comments.

Questions 17 and 18 were incorporated into the study to inquire into the effectiveness of university education and the APEGGA Member-In-Training process for preparing professional engineers and earth scientists for the ongoing learning requirements of professional practice. Response choices for the two questions were (*not effective, somewhat effective, effective,* and *very effective*). Question 18 applied only to respondents who were professional engineers as there has been no requirement for formal member-in-training induction for geologists and geophysicists. These two questions required a forced choice response and incorporated an open-ended component for explanatory comments. The purpose of this question was to assess the effectiveness of preservice university education and formal induction into professional practice as vehicles facilitating the ongoing learning which is required in contemporary professional practice.

Question 19 was a forced choice question which asked respondents how supportive their employers were in encouraging them to seek out formal continuing professional development opportunities. Response choices were (*not supportive, somewhat supportive, supportive,* and *very supportive*). This question was used as part of the information for discussing the role of formal continuing professional development in influencing learning in professional engineering and earth science practice.. The question also incorporated an open-ended section for explanatory comments.

Research Instrument - Sections III and IV

Questions 20 through 26 were used to capture demographic data about the sample. This information was used to develop a profile of professional characteristics. Specifically, the demographic data were used to develop a profile of respondents' primary work role, work location, travel schedule, age as an general indicator of the career stage, the discipline of university education and highest level of university degree achieved as well as completion of cooperative engineering education.

The final section (Section IV) of the research tool posed a series of three open ended questions on the nature of continuing professional development. The first question solicited feedback on the most pressing professional development needs of professional engineers and earth scientists today. The second question requested comments on improvements which were needed to facilitate continuing professional development for professional engineers and earth scientists in Alberta. The final question asked respondents to provide feedback on the kind of support required to assist professional engineers and earth scientists in pursuing professional development activities.

Pilot Testing

The research instrument was developed and then revised several times prior to to being pilot tested in early November 1995 with eleven professional engineers from Manitoba. In cooperation with the Executive Director of the Association of Professional Engineers of the Province of Manitoba (APEM), a list of seventeen APEM members was randomly generated and sent to the Executive Director of APEGGA in late October 1995. From this list, 11 professional engineers residing in Winnipeg were chosen to receive the research instrument for feedback about clarity in the presentation of questions, definitions, and the time it took to complete the questionnaire. Feedback was solicited using an instrument assessment sheet which was developed by the researcher for this purpose. Pilot testing packages, which included a detailed cover letter (Appendix B) that explained the study, the instrument assessment sheet, and a self-addressed stamped envelope, were sent from APEGGA's Edmonton office by courier to Winnipeg on November 9, 1995.

One completed pilot instrument was returned via facsimile transmission on November 16, 1995. Seven more of the completed pilot instruments were returned to the researcher by Canada Post regular mail prior to November 20, 1995. Feedback from eight of the eleven pilot instruments was incorporated into the final instrument for the main study.

Feedback obtained from the pilot included a self-report of the time it took to complete the instrument. Other feedback from the pilot respondents which was solicited related to the clarity and easy of understanding in the directions, the clarity of the questions, the clarity of the definitions, and problems related to completing the instrument. Based on the feedback received from the pilot group, the only specific changes made were editorial in nature. The average time which respondents in the piloted reported for completion of the instrument was approximately 25 minutes. This information was incorporated into the introduction section of the final research instrument.

A recipient of the pilot returned the instrument incomplete indicating insufficient time availability due to work and Christmas season obligations. Another pilot instrument was completed and returned in mid-December 1995. Feedback from this instrument was not used in completing the final research tool for the main study. Only one pilot instrument from the original eleven sent on November 16, 1995 was not accounted for.

Data Collection

Data collection for this study was influenced by several important dimensions which were considered within the context of the research methodology. These included a discussion on ethical considerations by which the researcher was bound, the sample and population used, and the timelines and process for distributing and handling returned questionnaires.

Ethical Considerations

This study was conducted according to the ethical guidelines established by the University of Alberta. To this end, ethical approval was sought by the Ethics Review Committee of the Department of Educational Policy Studies. An application for Research Ethics Review was made in early September 1995 and was granted by the members of the review committee on September 21, 1995. Permission to access the population of professional engineers and earth scientists in Alberta was made to the Association of Professional Engineers, Geologists, and Geophysicists of Alberta (APEGGA) on October 4, 1995.

A letter introducing the study and APEGGA's endorsement of the research was provided by APEGGA's Executive Director and Registrar, Mr. Robert Ross, P. Eng. (Appendix B). A separate transmittal letter from the researcher (Appendix B) accompanied all questionnaires sent to participants in the sample. This letter framed out the nature and purpose of the research. It also highlighted the significance of the study. The transmittal letter confirmed the voluntary nature of participation in the study and discussed procedures to be used to protect the anonymity of the respondents. Respondents were also informed that choosing to voluntarily complete and return the instrument constituted consent to participate in the study. The researcher anticipated that the individual respondents would in no way be harmed through their participation in the study.

Population and Sample

The population for the study represented professional members of the Association of Professional Engineers, Geologists, and Geophysicists of Alberta (APEGGA) who were registered and in good standing as of November, 1995. The population of professional members on APEGGA's membership roster in November 1995 included 20,822 Professional Engineers, 2,670 Professional Geologists, 908 Professional Geophysicists, and 77 professional members with dual membership, for a total of 24,477 professional members. From this population, 400 professional engineers, geologists, and geophysicists were selected from the APEGGA membership roster on November 24, 1995 through a proportional stratified sample which was randomly generated by a computer program by the member services unit at APEGGA. To assist in operationalizing this study, the researcher also obtained mailing labels and a master list for the sample from APEGGA's member services unit.

The sampling procedure was used to proportionally represent APEGGA's professional membership. Or as Leedy (1993) noted, proportional stratified sampling is used:

> ...to separate the several discrete elements in the total population and to select from each of the individual groups a random sample proportionately representative of the numerical strength of each of the components within the entire conglomerate (p. 210).

The composition of the sample included 343 professional engineers, 42 professional geologists, and 15 professional geophysicists. The computer generated sample represented a proportion of professional engineers, geologists, and geophysicists at 85.75%, 10.50%, and 3.75% respectively. The actual population distribution of professional engineers, geologists, and geophysicists for November 1995 was 85.06%, 10.90% and 3.07% respectively. The population proportion of professional members then, was virtually identical to the sample proportion. Members (n=77) holding dual membership were excluded from the sample frame. One of the 400 names which had been generated in the sample had been removed by APEGGA from the membership roster on November 24, 1995. This individual was removed from the sample as he no longer met the conditions for professional membership.

Data Collection

A total of 399 research packages were mailed to APEGGA members in the sample on November 25, 1995. Potential respondents received a package which contained the introduction letter from APEGGA, the researcher's transmittal letter, the research instrument, and a stamped, addressed envelope with which the results were to be returned to the researcher. The distribution and collection of research instruments were anticipated to take approximately four weeks.

The research instruments were individually numbered from 001 to 400 prior to distribution. As research packages were prepared for mailing, the identification number appearing on the research instrument was recorded against the individual recipient's name on the master address list the researcher held. The transmittal letter indicated this number was be used strictly for follow up purposes. The researcher worked with an assistant to prepare the 399 research packages for distribution. An initial return date of December 11. 1995 was indicated in the transmittal letter and on the research instrument. By December 17, 1995 ninety-seven (24.3%) of the research instruments were returned by mail.

The number of responses were monitored according to the speed and rate of return. Beginning on December 18, 1995 the researcher undertook a telephone follow-up campaign. Between December 22, 1995 and January 10, 1996. 177 follow-up telephone calls were made to respondents. Calls were only made to respondents who had phone numbers listed with APEGGA's member database. From the 177 follow up phone calls, 32 numbers were either not in service (21), the respondents had left the company (6), or they were otherwise not contactable (5). Of the 399 APEGGA professional members in the sample, there were 104 who had no phone number listed with APEGGA. These respondents received no form of follow-up and did not return a completed research instrument.

Returns

In total, 162 of the 399 distributed research instruments were returned as outlined in Table 3.1. Of these 162 questionnaires, 156 were usable for data analysis, representing a 39% response rate. Two respondents returned the research instrument incomplete and self-selected themselves out of the study by indicating a concern that they perceived themselves as unsuitable respondents to complete the survey due to current unemployment. Three other recipients phoned the researcher to indicate they deemed themselves to be unsuitable for the study due to their being retired from active engineering practice. Three other research packages were returned to the researcher unopened, without explanation. The response rate was considered reasonable and acceptable for this study.

Table 3. 1: Response Rate

Research Instrument	Total	Percentage
Returned useable	156	39.1
Returned unusable	6	1.5
Not returned	237	59.4
	399	100.0

Data Analyses

The data analyses for this study was conducted through a four phase approach. The first phase involved receiving the completed questionnaire, confirming the respondent's participation against the master list, and coding the data. The second phase involved the keying and verification of the quantitative data by Accurate Data Services, a third-party commercial vendor who prepared the data file. The third phase involved the development of an SPSS for Windows data file for managing and manipulating the data. This phase also involved importing and matching the raw data keyed and verified with the commercial vendor to the parameters of the SPSS for Windows file. This phase also involved the preparation of the qualitative data for analysis. The final phase involved the actual data analysis. All phases were completed by the researcher unless otherwise indicated.

Organization of the Data

The completed and returned research instruments were reviewed and the data from the closed ended questions were coded for statistical analyses. The researcher retained a commercial vendor to key and verify the coded data into a flat ASCII electronic file format. An SPSS for Windows data file was used to manage the quantitative data analyses, which used descriptive statistics for analysis. The researcher reviewed and confirmed the integrity of the data prior to in-depth statistical analysis.

The qualitative data from the comment section and the final three open-ended responses were entered into Microsoft Word files. The researcher then used a combination of the key word searching feature in the word processing package as well as a personal review of the printed copies of the qualitative data to generate themes for the open ended responses. The personal review involved searching for complementary ideas, issues, and synonyms that would not readily be identified using the key word search function. The issues were then manually organized and tabulated according to emergent themes. All data are organized and presented in chapter IV according to the research questions.

Analyses of Data

This study produced quantitative and qualitative data. The quantitative data related to activities professional engineers and earth scientists use to maintain competence, factors related to continuing professional development as well as the professional work environment, and demographic information. Qualitative data were generated to clarify responses to five closed questions and to provide greater insight into three questions about the most pressing professional development needs of APEGGA members, what improvements could be made in facilitating professional development for APEGGA members, and what kinds of support were required to assist APEGGA members in pursuing professional development activities.

The basic quantitative analysis for this study was initially limited to descriptive statistics, including frequencies, means, ranges, percentages, and standard deviations for each variable.

Summary

A descriptive survey method was used to gather data from 399 professional engineers and earth scientists were surveyed in December 1995. Descriptive statistics were utilized to analyze the data from closed ended questions. A thematic and frequency analysis was performed on the open ended information.

CHAPTER IV

PRESENTATION OF DATA ANALYSES

The purpose of this study was to identify specific learning activities professional engineers and earth scientists in Alberta used to perform in response to changing conditions in their professional work environments. Primary factors considered within the study included conditions of the professional work environment which influenced performance, facilitators and inhibitors of learning, and opportunities for learning within the professional work environment. Data were collected to answer the following research questions:

1. Which learning activities do professional engineers and earth scientists find important for developing and maintaining competence?
2. What professional work environment conditions do engineers and earth scientists find important in developing and maintaining competence?
3. What factors influence learning in professional engineering and earth science practice?

A descriptive survey method was used for this study. A questionnaire based research instrument was used for the data collection tool. A proportional stratified sample of 399 Alberta professional engineers and earth scientists was surveyed by mail on November 2[illegible], 1995. A total of 156 usable questionnaires were returned for a response rate of 39.1%. The data analysis was achieved primarily through the use of descriptive statistics. Qualitative data were analyzed through the frequency of responses and organized into emerging themes.

The chapter presents the results of the data analyses which were obtained through the methods described in detail in Chapter Three. The chapter is organized according to the research questions outlined above with a summary of the findings.

Demographic Profile

The sample used for this study was representative of APEGGA's professional member population, as highlighted in Table 4.1.

Table 4.1: Demographic Comparison

Demographic Variables	Survey Response (%)	Sample (%)	Variance (%)
Member Type			
P. Engineer	85.9	85.7	+ 0.2
P. Geologist	9.6	10.5	- 0.9
P. Geophysicist	4.5	3.8	+ 0.7
Age			
20-29	9.1	3.8	+ 5.3
30-39	29.5	32.3	- 2.8
40-49	40.3	35.2	+ 5.1
50-59	14.9	18.5	- 3.6
60-69	5.8	9.3	- 3.5
> 70	0.3	0.8	- 0.5
Location			
Calgary	61.5	70.3	- 8.8
Edmonton	14.8	13.2	+ 1.6
Fort McMurray	7.7	5.3	+ 2.4
Other Alberta	16.0	11.2	+ 4.8

Demographic characteristics relating to professional member type, the respondents' age distribution, and their mailing location in Alberta were analyzed and compared against demographic information for the study's sample. Based on a comparative analysis of the demographic variable of professional member type presented in Table 4.1, there was negligible variation between the survey responses and the sample. There was some variation in the age category demographics. Respondents in the 20 - 29 year age category and in the 40 - 49 year age category responded in greater numbers than professional members in the sample frame who tended to be older.

Of the 156 respondents, 136 (87.2%) reported their location of work was in a major centre with more than 25,000 people. Demographic information was also collected about how frequently respondents' work took them away from their primary locations of work. It was anticipated that respondents whose work took them away more frequently might view formal continuing professional development activities less favorably due to scheduling difficulties and uncertainty about being able to consistently attend programs with longer formats. To this end, 7.7 % of respondents indicated their work never took them away from the primarily location of work, 64.1% noted their work occasionally took them away, 16.0% reported their work took them away regularly, and 11.5% indicated their work took them away frequently from their primary location of work.

Table 4.2 outlines data related to educational variables about the sample. In reporting the highest level of university education achieved, 122 (78.2%) of respondents indicated they held a Bachelor degree, 26 (16.7%) reported they held a Master's degree and 7 (4.5%) held Doctoral degrees. When asked if they had participated in a cooperative education program, 18 (11.5%) respondents indicated they had participated in such a program while 138 (88.5%) reported they had not participated in a cooperative education program. This response is consistent with the relatively new incorporation of cooperative education into the preservice engineering curriculum. It also reflects the limited availability of cooperative education opportunities within university engineering programs.

Table 4.2 Educational Characteristics

Educational Variable	Frequency	% of Valid Respondents
Highest Level of University		
Bachelor Degree	122	78.2
Master's Degree	26	16.7
Doctorate	7	11.5
Cooperative Education		
No	138	88.5
Yes	18	11.5
Technical Discipline		
Mechanical Engineering	33	21.2
Chemical Engineering	27	17.3
Civil Engineering	26	16.7
Electrical Engineering	23	14.7
Petroleum Engineering	10	6.4
Mining Engineering	5	3.2
Industrial Engineering	1	0.6
Other Engineering	12	7.7
Geology	14	9.0
Geophysics	4	2.6

For those reporting an *Other* response to the technical discipline question, respondents studied, Geological Engineering (n = 4), Agricultural Engineering (n = 3), Metalurgical Engineering (n = 1), Engineering Physics (n = 1), Geotechnical/Mining Engineering (n = 1), and Bio-resource Engineering (n = 1) were the technical university disciplines reported.

Table 4.3 highlights the roles respondents hold. The majority (63.2%) of respondents can be classified as practicing in technically-based, professional roles. This classification was established by aggregating the practicing engineer (company-based), consulting engineer (external client), practicing geologist, practicing geophysicist, and other categories listed in Table 4.3.

Table 4.3 : Primary Roles Employed In

Primary Role	Frequency	% of Respondents
Practicing Engineer (company-based)	57	36.5
Managerial (supervisory, manager, executive)	47	30.1
Consulting Engineer (external clients)	26	16.7
Practicing Geologist	8	5.1
Retired but maintain APEGGA membership	5	3.2
Practicing Geophysicist	3	1.9
Unemployed	3	1.9
Other	6	3.8

The demographic profile, then, highlights that according to APEGGA member type, age, and location, the survey response is representative of the sample. The sample in turn, was generated through a computer program which created a proportional stratified sample representative of the APEGGA professional member population.

Learning Activities Important to Maintaining Professional Competence

The first research question in this study focused on the learning activities professional engineers and earth scientists reported using to help them develop and maintain professional competence. In the area of technical competence, defined for respondents in the definition list (Appendix A), 28 discrete activities were listed. Respondents employed in managerial roles were also asked to rate 13 activities used to develop and maintain managerial competence, which was also defined. The inventory of activities was based on previous research conducted in the United States by Cervero, et al. (1986) and Jones and LeBold (1987).

The activities in Questions 5 and 6 which related to developing and maintaining professional competence were categorized into variables that the researcher then classified as formal and informal learning, pursuant to the theoretical discussion in Chapter II. One category was created for formal learning activities. This category included educational programs as well as professional organization meetings and situations where respondents prepare and make technical presentations before their peers. Within the area of informal learning activities, variables were grouped into categories to highlight action-in-practice (inherent in the nature of a job assignment); consultative (both with other people as well as print and other media); and other informal activities which did not fall within the other sub-categories.

Technical Competence

In this section, the data are reported and discussed related to the learning activities used to develop and maintain technical competence. The data for this section, gathered from Question 5 of the research instrument, were scored using a four-point Likert scale which ranged from 1 (*not important*), 2 (*somewhat important*), 3 (*important*), and 4 (*very important*). A fifth, 5 (*does not apply*) category was used to isolate variables which did not apply to individual respondents. The (*does not apply*) items were removed from the descriptive data analysis as the four-point Likert scale was designed as a continuous variable. Table 4.4 presents these data in rank order according to the mean scores and standard deviations. Of the top 10 activities, eight were related directly to practice. This finding suggests that informal activities inherent in the nature of a job assignment as well as informal consultative activities are valued as activities for developing and maintaining technical competence.

Activities such as drawing on personal skill and knowledge (M = 3.45, SD = .67), job assignments that constantly challenge overall technical competence (M = 3.15, SD = .81), informal contact with coworkers (M = 3.04, SD = .70), receiving advice from a supervisor or coworkers (M = 2.99, SD = .84), and working with a team to make decisions about a project (M = 2.99, SD = .84), were ranked as the activities most important, relative to the list of 28 discrete items in Question 5, for developing and maintaining technical competence.

Table 4.4: Activities for Developing and Maintaining Technical Competence

Learning Activity	Category	Mean	SD
Draw on personal skill and knowledge (*n* = 151)[1]	Informal(Action-in-Practice)	3.45	.67
Job assignments that constantly challenge overall technical competence (*n* = 150)	Informal(Action-in-Practice)	3.15	.81
Informal contact with coworkers (*n* = 146)	Informal(Action-in-Practice)	3.04	.70
Receive advice from a supervisor or coworker (*n* = 146)	Informal (Consultative)	2.99	.84
Experiment with different approaches to problem (*n*= 149)	Informal(Action-in-Practice)	2.99	.84
Work with team to make decisions about project (*n* = 140)	Informal(Action-in-Practice)	2.94	.85
Attend workshops and seminars (technical) (*n* = 152)	Formal (Ed. Programming)	2.91	.83
Job assignments that constantly challenge specific specialty areas of technical competence (*n* = 149)	Informal(Action-in-Practice)	2.83	.92
Refer to a technical publication (*n* = 151)	Informal (Consultative[2])	2.79	.79
Consult an external technical report (*n* = 152)	Informal (Consultative[2])	2.78	.78
Consult a handbook (*n* = 151)	Informal (Consultative[2])	2.69	.88
Consult with a manufacturer's representative (*n* = 147)	Informal (Consultative)	2.67	.94
Seek out internal expert to explain project report (*n* = 138)	Informal (Consultative)	2.64	.97
Consult an internal technical report (*n* = 143)	Informal (Consultative[2])	2.62	.88
Informal contact with other professional engineers or earth scientists outside your work (*n* = 150)	Informal (Other)	2.57	.86
Read an engineering or earth science periodical (*n* = 153)	Informal (Consultative[2])	2.53	.88
Seek out an external expert to explain a project report (*n* = 144)	Informal (Consultative)	2.51	.90
Attend workshops and seminars (manag. dev.) (*n* = 139)	Formal (Ed. Programming)	2.50	.87
Consult a catalogue or manufacturer's literature (*n* = 148)	Informal (Consultative[2])	2.48	.93
Request an assignment to a particular project for needed experience (*n* = 136)	Informal(Action-in-Practice)	2.40	.90
Attend a convention of professional organization (*n* = 151)	Formal (Ed. Programming)	2.30	.92
Prepare and make a technical presentation before an engineering or earth science related group (*n* = 143)	Formal (Ed. Programming)	2.26	1.01
Consult videotape, software, or electronic media (*n* = 144)	Informal (Consultative[2])	2.04	.79
Rehearse some useful skill on the job (*n* = 139)	Informal(Action-in-Practice)	2.03	.74
Consult a dictionary of technical terminology (*n* = 147)	Formal (Ed. Programming)	1.89	.87
Attend university-sponsored credit courses (*n* = 136)	Informal (Other)	1.79	.94
Complete formal self-study programs (*n* = 131)	Informal (Consultative[2])	1.62	.77

<u>Note.</u> [1] Number of valid responses for each variable [2] Consult print or non-human resource

Managerial Competence

Table 4.5 presents mean scores and standard deviations for 13 items used to develop and maintain managerial competence. This question was intended exclusively for respondents working in supervisory or managerial roles, hence the relatively lower response rate. This question, Question 6, used the same four-point Likert scale employed for the previous question about activities used to develop and maintain technical competence.

Table 4.5: Activities for Developing and Maintaining Managerial Competence

Learning Activity	Category	Mean	SD
Draw on personal skill and knowledge (n = 91)[1]	Informal(Action-in-Practice)	3.30	.69
Informal contact with colleagues at your place of work (n = 90)	Informal(Action-in-Practice)	2.89	.81
Attend workshops and seminars (Manage dev). (n = 90)	Formal (Ed. Programming)	2.73	.90
Consult an internal expert (n = 85)	Informal (Consultative)	2.65	.90
Consult an external expert (n = 91)	Informal (Consultative)	2.53	.96
Informal contact with colleagues outside work (n = 90)	Informal (Other)	2.52	.93
Attend In-house courses (n = 82)	Formal (Ed. Programming)	2.35	.92
Attend workshops and seminars (Technical) (n = 90)	Formal (Ed. Programming)	2.30	.89
Consult a reference text (n = 91)	Informal (Consultative[2])	2.00	.84
Consult a periodical (n = 90)	Informal (Consultative[2])	1.98	.89
Complete formal self-study programs (n = 83)	Informal (Other)	1.65	.83
Attend university-sponsored credit courses (n = 86)	Formal (Ed. Programming)	1.70	.92
Consult a handbook (n = 91)	Informal (Consultative[2])	1.85	.88

Note. [1] Number of valid responses for each variable [2] Consult print or non-human resource

Overall, mean scores for the top five items in this question were lower than in the previous question on technical competence, suggesting the degree of importance placed on activities used to develop and maintain technical competence maybe higher than activities used to develop and maintain managerial competence.

Drawing on personal skill and knowledge (*M* = 3.30, *SD* = .69), informal contact with colleagues at work (*M* = 2.89, *SD* = .81) were ranked as the top two activities used to develop and maintain managerial competence. Attending management development workshops and seminars (*M* = 2.73, *SD* = .90), consulting an internal expert (*M* = 2.65, *SD* = .90) and consulting an external expert (*M* = 2.53, *SD* = .90) were the next highest ranked items. These results are consistent with what one might expect to see in a cohort with a predominantly technical background. Developing professional competence in a managerial capacity requires knowledge and skills that are not usually integrated into existing preservice university engineering curricula. It follows that much of the foundational knowledge which professional engineers and earth scientists require as they move into managerial roles is acquired after university, and preferably through certain activities rather than others. This most likely explains the higher ranking in this question for attending workshops and seminars as well as consultation with internal experts and experts external to a company.

To summarize the findings from the first research question, then, respondents did report a range of activities as being important to developing and maintaining professional competence. Commonly held views among practitioners in particular, holds that learning on-the-job through action-in-practice and consultation are powerful tools for developing and maintaining professional competence. The analyses and findings from this research question appear to represent the first major systematic inquiry into the formal and informal activities reported by Alberta engineers and earth scientists for developing and maintaining competent professional performance.

Professional Work Environment Conditions

The second research question in this study was concerned with professional work environment conditions that professional engineers and earth scientists find important for competent professional performance. This section presents data analysis related to work environment factors considered important for conducting work effectively. Data are also presented based on an inquiry as to whether respondents have experienced an increase in complex engineering and earth science problems which have no easy solutions. An examination of the number of times that respondents' experienced a need for information, knowledge, and skills that could not be readily met is also presented in this section. Finally, information related to who respondents believe should responsible for maintaining professional competence is also presented.

Work Environment Factors for Conducting Work Effectively

Work environment factors considered important for conducting work effectively were identified from previous work completed by Cervero, et al. (1986) and Jones and LeBold (1987) and are presented in Table 4.6. This question, Question 2 of the research instrument, required respondents to rank items according to a four-point Likert scale which ranged from 1 (*not important*), 2 (*somewhat important*), 3 (*important*), and (4) (*very important*). A fifth, 5 (*does not apply*) category was added to isolate variables which respondents felt did not apply to their individual situations. The items which did not apply were removed from the analysis. The valid responses for each variable appear in Table 4.6 immediately following the variable label.

Table 4.6: Factors For Conducting Work Effectively

Work Environment Factor	Mean	SD
Sufficient time/opportunity to communicate internally with co-workers (n = 149)	3.15	.78
Sufficient support from technical personnel (n = 149)	3.14	.85
Up-to-date computer equipment and facilities (n = 155)	3.01	.76
Ready access to new technical information (n = 154)	2.87	.76
Up-to-date technical equipment and facilities (n = 140)	2.69	.93
Sufficient time/opportunity to communicate externally with colleagues (n = 152)	2.49	.79
Sufficient time/opportunity to attend professional development activities (n = 151)	2.40	.86
Sufficient support of non-technical personnel (n = 149)	2.37	.92
Ongoing investment in company sponsored research and development (n = 126)	2.33	.97
Career guidance (n = 139)	1.79	.85

The mean scores of the top three items were ranked between 3 (*important*) and 4 (*very important*). Sufficient time and opportunity to communicate internally with co-workers (M = 3.15, SD = .78) was ranked most important for conducting work effectively. Sufficient support from technical personnel (M = 3.14, SD = .85), up-to-date computer equipment and facilities (M = 3.01, SD = .76), ready access to new technical information (M = 2.87, SD = .76), as well as up-to-date technical equipment and facilities (M = 2.69, SD = .93) rounded out the top five factors for conducting work effectively.

The reporting of sufficient time and opportunity to communicate internally with co-workers as the most important factor for conducting work effectively is also consistent with the informal activities reported as most important for developing and maintaining technical and managerial competence. These included informal contact with coworkers, receiving advice from a supervisor or co-worker, and working with a team to make decisions about a project.

Other items reported in the open-ended comment section of Question 2 included quiet and adequate work space, flexibility and autonomy in scheduling, sufficient time to work on projects, and good relationships with co-workers.

Complex Engineering and Earth Science Problems

An assumption about contemporary professional practice, championed and popularized by Schön (1983), is that professionals are experiencing an increase in practice-related problems which are complex, laden with ambiguity, and which have no easy solutions. Question 15 of the survey examined this phenomenon in engineering and earth science practice in Alberta. In addition to the closed-ended responses, which appear in Table 4.7, 31 (19.8%) respondents provided explanatory comments in the open-ended section of this question.

Table 4.7: Complex Engineering and Earth Science Problems

Increase in "Complex" Practice-based Problems	% of Respondents
Yes	48.0
No	33.6
Not Really Sure	18.4

In part one of the question, 48.0% of respondents indicated they were experiencing an increase in complex engineering and earth science problems to which there were no easy solutions. Another 33.6% of respondents indicated they were not experiencing an increase in complex problems and an additional 18.4% indicated they were not sure. These results may be an understatement of the actual increase in complexity of professional problems which have no easy solutions. From the nature of several open-ended responses, it appears professional pride may have been a mitigating factor which elicited a relatively conservative position on this question from many respondents. This was clearly articulated by one respondent who stated "solutions have never been easy. If it was easy, they would not need us."

Other open-ended responses provided in the *comments* section of this question offer deeper insight into the nature of many of the complex problems that are being experienced in contemporary engineering and earth science practice. Three overarching themes emerge from the responses.

The first theme is related to physical environmental and public safety considerations. Twelve (38.7%) of the 24 open-ended comments from this question related directly to environment and public safety. As one respondent noted "everyone is concerned about the environment and safety, however, there is no quick and simple solutions. It also involves 'complex' engineering and cost."

A second theme which emerged from the qualitative data for this question involves cost control, most often underlying financial and ethical issues related to technical work. It appears that cost control issues are frequently intertwined with design and regulatory issues. This was most effectively captured by one respondent who suggested "the best solution is usually outside the budget, so one must compromise in one area but stay within the regulations."

A third theme related to complex engineering and earth science problems ranked closely to the second theme in terms of the frequency of responses. This theme related to an increase in technical complexity in the workplace brought about by new computer software and hardware intended to improve engineering and earth science work. The nature of the comments indicated, however, an interesting paradox. This paradox was articulated by one respondent who indicated that he "had experienced a dramatic development in computer technology/software that enables more sophisticated analysis of complex problems, which in turn places greater demand on the engineer to address even more complex issues." It would appear, then, that some of the tools which are intended to assist in conducting work more effectively may have an unintended effect which invites new levels of complexity to enter into the professional work environment.

Based on the closed-ended and open-ended responses to Question 15, it would appear many professional engineers and earth scientists are in fact facing an increase in the nature of complex professional problems to which there are no easy solutions.

Unmet Needs for Information, Knowledge, or Skills

A related question to the increase in complex problems in professional practice to which there are no easy solutions, involves the number of times professional engineers and earth scientists experience a need for information, knowledge, or skills that can not be readily met. This question, which appeared as Question 16, asked respondents how many times in the past three months they experienced a need for information, knowledge, or skills that could not be readily met. The results from this question are presented in Table 4.8.

Table 4.8: Unmet Need For Information, Skills, and Knowledge
(n = 153)

# of Times in Last 3 Months	Frequency	% of Respondents
1 - 3 times	74	48
4 - 6 times	22	14
7 - 9 times	4	3
10 - 12 times	7	5
13 - 15 times	1	1
> 15 times	3	2
Does Not Apply	42	27

It part one, 74 (48%) respondents indicated they had experienced a need for information, knowledge, or skills at least one to three times in the last three months which could not be readily met. Another 22 (14%) indicated they had experienced a need for information, knowledge, or skills at least 4-6 times in the last three months that could not be readily met.

In part two of Question 16, respondents were asked to provide open-ended comments explaining their responses to part one. Twelve (7.6%) of the respondents furnished explanatory comments. The themes that emerged relate largely to the nature of organizational resources. Comments such as "did not get definite answers from the experts," "colleagues who could help commonly are too busy to help in a downsized work environment" and "to keep current in some skill areas, one needs to be in a job or work environment properly supported with personal computers, work stations, communication facility access or other tools and instrumentation as appropriate" characterized the nature of comments in this area.

Other comments related to the need to know where information can be located and easily accessed. To this end some employers have organized data bases and other learning resources which engineers and earth scientists can access to complete their work. Yet, there are also situations being encountered which are entirely new. For example, one respondent shared that the "development of a plan for affecting a gas pipeline shutdown and restart required some intense effort to overcome computer modeling limitations and general non-experience in such procedures."

The nature of responses to this question reinforces the findings made about there being an increase in the complexity of engineering and earth science problems for which there are no easy solutions. It appears many of the resources required for effective practice may be increasingly difficult to access in professional work environments.

Responsibility for Maintaining Competence

In Question 13 of the survey, respondents were asked who should be responsible for maintaining the competence of engineers and earth scientists. Table 4.9 outlines the results of this question. Responsibility for maintaining competence was seen to be an equally shared responsibility of the employer and the APEGGA professional member among 71 (45.8%) of the respondents. Another 54 (34.8%) of respondents indicated that it was the professional member more so than the employer who should be responsible for maintaining competence.

Table 4.9: Responsibility for Maintaining Competence
($n = 155$)

Responsible for Competence	Frequency	% of Respondents
Equally shared responsibility of employer and professional member	71	45.8
More professional member than employer	54	34.8
Professional member only	12	7.7
Employer more than professional member	8	5.2
Other	7	4.5
Employer only	2	1.3
No opinion	1	0.6

In fact, 88.3% of the respondents viewed professional members as having a substantial individual responsibility for maintaining professional competence. In six of the seven comments listed in the *other* category, respondents indicated they believed that APEGGA has the responsibility for maintaining professional competence.

The results from the second research question indicate there are important work environment factors that enable engineers and earth scientists to conduct their work effectively. These activities are also related to activities reported as important to developing and maintaining professional competence. Chief among these items is time and opportunity to communicate internally with coworkers. This work environment factor applies to many of the top ranked activities related to developing and maintaining professional competence which are summarized in Table 4.4 and Table 4.5.

The results of Question 15 and 16 also indicate there appears to be an increase in complex engineering and earth science problems to which there are no easy solutions. The reporting of the number of times respondents had experienced a need for information, knowledge, and skills in the previous 3 months would also tend to support the notion that the professional work environment is becoming more complicated. Nevertheless, respondents also tended to support the notion that APEGGA professional members do have an individual role and responsibility for maintaining competence.

Factors Affecting Professional Learning

The third research question that guided this study was concerned with factors which affect professional learning. These included an examination of the reasons why engineers and earth scientists seek out new information (Question 1) as well as the perceived effectiveness of several learning activities (Question 10). Content areas where respondents felt a need for more structured approaches to learning were also explored (Question 4).

The respondents' positions on mandating continuing professional education were examined (Question 12) with attention paid to the reasons respondents felt continuing professional education should or should not be mandated. A series of statements and responses which probed attitudes towards continuing professional development (Question 14) are also presented. The effectiveness of university preservice (Question 17) and APEGGA's Member-in-Training (Question 18) process for preparing practitioners for the ongoing learning requirements of contemporary professional practice is also reported. Finally, a synopsis of factors related to previous formal continuing professional development is discussed.

Data analysis in this section, then, is largely used to provide a context and frame of reference for factors which were identified in the study's first two research questions. The factors discussed in this section were examined as the researcher suspected several of these factors could mitigate the learning choices and preferences.

Reasons for Seeking Out New Information

Data were gathered on the reasons that professional engineers and earth scientists seek out new information. This question, which appeared as Question 1 in the survey instrument, was a multiple response question. Respondents had the option of making up to seven discrete choices. Respondents also had the option of offering additional reasons by completing an *Other* category. The data are presented in Table

4.10 according to the number of times each discrete variable was reported and the percentage of total respondents who chose each discrete variable.

The top two reasons given by respondents for seeking out new information was to acquire new knowledge (n = 134) and to update existing knowledge (n = 113). Acquiring new skills (n = 100), generally being abreast and aware of advances (n = 100), and understanding technical advances in a practitioner's field or industry (n = 96) rounded out the list of reasons more than 62% of respondents gave for seeking out new information.

Table 4.10: Reason For Seeking New Information
(n = 154)

Reason for Seeking New Information	# of Times Reported	% of Total Respondents
Acquire new knowledge	134	87
Update existing knowledge	113	73
Acquire new skills	100	65
Keep abreast and aware of advances for general information	100	65
Understand technical advances in your field or industry	96	62
Update existing skills	90	58
Reinforce you are doing things correctly	65	42
Other	11	7

Three themes emerged out of the 11 additional comments reported in the *Other* category. These themes included seeking out new information for personal or professional interest, competitive positioning, and preparing for new project commencement.

Perceived Effectiveness of Learning Activities

Question 10 of the survey was used to gather data regarding how effective respondents' believed a range of learning activities, which can be categorized as formal and informal, were. A four-point Likert scale, which ranged from 1 (*not effective*), 2 (*somewhat effective*), 3 (*effective*), and 4 (*very effective*), was used for scoring. The data analyses for this question are presented in Table 4.11 with the nine learning activities ranked according to the mean score.

Table 4.11: Effectiveness of Learning Activities

(n = 153)

Activity	Learning Type	Mean	SD
Practice in an engineering, geological, or geophysical job	Informal	3.63	.54
Discussion with knowledgeable people	Informal	3.33	.64
Full-day courses (regular day program)	Formal	3.03	.82
Intensive short courses	Formal	2.98	.78
Reading technical books, articles, papers, etc.	Informal	2.76	.71
Seminars, conferences	Formal	2.71	.82
Evening courses	Formal	2.47	.84
Tapes (audio or video)	Informal	1.94	.69
Correspondence courses	Informal	1.93	.74

Consistent with other findings in this study, practice in an engineering, geological, or geophysical job (M = 3.63, SD = .54) as well as discussion with knowledgeable people (M = 3.33, SD = .64) were considered to be the most effective learning activities from the list; these are categorized as informal learning activities.

Full day courses (*M* = 3.03, *SD* = .82) and intensive short courses (*M* = 2.98, *SD* = .78) were reported to be the two most effective formal learning activities.

Overall, the top three activities were reported as being 3 (*effective*) to 4 (*very effective*) learning activities according to the categories created for this question by the researcher.

Structured Approaches to Learning

This question, which appeared as Question 4 in the survey, asked respondents to rate their need for structured approaches to learning. The term structured approaches to learning was identified for respondents in the list of definitions which accompanied the study. A four-point Likert scale, which ranged from 1 (*no need*), 2 (*some need*), 3 (*need*), and 4 (*highly needed*), was used to score this question. The data are presented in Table 4.12 according to their mean score and standard deviation.

The relatively lower response to this question compared to other questions in the survey, along with the relatively lower mean scores indicates that the need for structured approaches to learning in the identified content areas may not be an issue of overriding concern for respondents.

Consistent with other issues arising out of the data, the top ranked areas included their own branch of engineering or earth science (*M* = 2.59, *SD* = .90), management practice (*M* = 2.58, *SD* = .84), environmental technologies (*M* = 2.31, *SD* = .85), and matters which are financial in nature (*M* = 2.30, *SD* = .83). The relatively lower mean scores for items in this question would suggest that generally, there is only 2 (*some need*) to 3 (*need*) according to the categorical scale created for this question. Overall, there would not appear to be a high need for structure in the content areas identified in this question.

Table 4.12: Need for Structured Learning Approaches
(*n* = 138)

Content Area	Mean	SD
Your branch or engineering, geology, or geophysics	2.59	.90
Management, administration, or related	2.58	.84
Environmental technologies	2.31	.85
Accounting, finance, costing, cost control, etc.	2.30	.83
Technically oriented computer technologies	2.24	.90
Personnel, industrial relations, and related	2.15	.90
Another branch of engineering, geology, or geophysics	2.09	.79
Quality control (e.g., TQM, ISO 9000)	2.08	.87
Law and related	1.94	.76
General culture and/or humanities	1.66	.73

Mandatory Continuing Education

Question 12 of the survey was based on a similar question asked in the 1981 survey APEGGA commissioned on continuing education in professional engineering and earth science practice (APEGGA, 1981, November). The question was asked, in part, to see if there would be a material difference in responses to the issue of mandatory continuing education in light of the profound structural changes which have been reported in engineering and earth science practice in Alberta (APEGGA, 1995, April). Part one of the question asked respondents whether or not continuing professional education should be mandated as a condition of professional practice for APEGGA members. The results of this part of the question are presented in Table 4.13. In a comparison of 1996 and 1981 data, there is very little variation in the attitudes among respondents for a mandatory continuing professional education requirement for APEGGA members.

Table 4.13: Mandatory Continuing Education

Mandatory Continuing Education	Frequency	% of Respondents	1981 Survey (%)
No	102	65.4	61.7
Yes	45	28.8	33.6
No Opinion	9	5.8	4.7

Responses to the second part of the question depended on one's previous answer to the first part. Those opposing a mandatory continuing professional education requirement were asked to indicate their reasons. These are outlined in Table 4.14 and are ranked by the number of times they were reported. This section allowed for a multiple response which means that a respondent could give no reason, one reason, or several reasons. Therefore, the number of times an item was listed is reported along with the total percentage of *no* respondents who identified a reason for not mandating continuing professional education.

The top reasons given for not mandating continuing professional education for APEGGA professional members were consistent between the 1981 study and this study. Respondents indicated the top reasons for not mandating continuing professional education were that APEGGA members keep current at any rate in order to keep their job or remain competitive (n = 74) and they also voluntarily keep up-to-date as a matter of professional pride (n = 47).

Table 4.14: Reasons For Not Mandating CPE
(n = 104)

Reasons For Not Mandating CPE	Rank 1981	Rank	# of Times Reported
Members keep current to maintain job/remain competitive	1	1	74
Members remain voluntarily competent as a matter of professional pride	2	2	47
Tremendous effort and cost with little benefit	7	3	46
Results of continuing learning cannot be easily measured	5	4	42
Members are expected/required by employers to do CPE	4	5	41
It would encourage "doing things to get CEU points"	6	6	35
Members remain competent to ensure public safety	-	7	30
Members remain competent to avoid civil litigation	3	9	21
Other	8	8	29

Other top reasons, established through the number of times reported, which were cited for not mandating continuing professional education in the present study included the belief it would involve tremendous effort and cost with little benefit (n = 46), the results are not easily measured (n = 42), and engineers and earth scientists are presently expected to engage in ongoing professional development by their employers.

There were 29 *Other* comments offered for not mandating continuing professional education. By far the most frequent comment (n = 14) related to a concern that legislating a mandatory continuing education requirement would create a further bureucractic mechanism and further threats to professional autonomy that would not ensure competence. Other responses reflected the theme that the marketplace self-selects out practitioners who do not remain competent. Yet other responses related to the fact that the engineering and earth sciences are professions which are sufficiently diverse that a mandatory professional education requirement would be too large an undertaking to execute effectively. Finally, one respondent indicated that the nature of his overseas work schedule would simply not permit participation in a mandatory continuing professional education program.

The next part of Question 12 applied to those respondents who reported *yes* to to agreeing with a mandatory continuing education requirement for professional engineers and earth scientists. Table 4.15 outlines the reasons respondents indicated for agreeing to a mandatory continuing professional education requirement. The top three reasons given were also consistent between the 1981 study and the present study.

The top reason focused on the lack of an existing mechanism for ensuring that an engineer or earth scientist remains competent once he/she has received professional status from APEGGA. The reason receiving the second highest number of responses was that a mandatory continuing education requirement would be an adequate way of meeting public expectations for accountability that APEGGA members remain professionally competent. The third reason cited for mandating continuing professional education was that APEGGA members needed an objective standard to strive for and that mandatory continuing professional education would be one way vehicle for objective standards.

Table 4.15: Reasons For Mandating CPE
(n = 44)

Reasons For Mandating CPE	Rank 1981	Rank	# of Times Reported
No mechanism now exists to ensure ongoing competence	1	1	33
Adequate for meeting public expectations of competence	2	2	22
Members need an objective or standard to strive for	3	3	14
It would be another positive stimulus, another incentive	5	4	11
Professional development can be adequately measured	4	6	4
Other	6	5	5

An additional five comments appeared in the *Other* section of this part of Question 12. Three of these respondents perceived a mandatory continuing education requirement as a vehicle for keeping pace with technological change. One respondent indicated a mandatory education requirement "would discourage riding it out until retirement" and one other respondent thought it "would enhance the prestige of the professional designation."

Attitudes Towards Continuing Professional Development

An examination of attitudes related to continuing professional development was one of the factors the researcher considered important in gauging how engineers and earth scientists responded to learning and changes in professional practice. To this end, a series of eight attitudinal statements were posed. Question 14 invited respondents to rate how strongly they agreed with each statement and was scored using the following four-point Likert scale: (1) *strongly disagree*, (2) *disagree*, (3) *agree*, and (4) *strongly agree*. Findings are presented in Table 4.16

Table 4.16: Attitudes Towards Continuing Professional Development

(*n* = 152)

Statement	Mean	SD
A variety of challenging job assignments helps improve engineering, geological, or geophysical skill and knowledge.	3.46	.54
After leaving university, engineers, geologists, and geophysicists must pursue their professional development by means of continuing professional development (formal and informal).	3.30	.59
I consider myself to be up-to-date with the latest technological developments in my field of specialization.	2.94	.63
Employers, universities, and other providers offer enough activities to meet the professional development needs of engineers, geologists, and geophysicists on a timely, relevant basis.	2.74	.70
In my organization, taking part in formal continuing professional development is regarded as an important criterion for engineers, geologists, and geophysicists.	2.70	.81
The undergraduate engineering, geological, or geophysical education I received was well suited to contemporary job market needs.	2.59	.78
It would be useful for APEGGA to grant "continuing education units" for formal and informal continuing professional development that engineers, geologists, and geophysicists undertake.	2.49	.88
In general the very fact that an engineer, geologist, or geophysicist is working in engineering, geology, or geophysics is sufficient to guarantee the development and maintenance of competence.	2.08	.65

The results from this question indicate that overall respondents agree with the statement that a variety of challenging job assignments help improve engineering and earth science skill and knowledge (*M* = 3.46, *SD* = .54). The results from this statement are consistent with other findings in this study. Specifically, it is related to the results from Question 5 and 6 of the survey, where the nature of a job assignment is viewed strongly as contributing to professional competence.

Given the position of the first and final statements appearing in Table 4.16, the implication is that a range of formal and informal activities are required to develop and maintain professional competence. Interestingly, it appears that overall, respondents tend to disagree that practicing in an engineering or earth science role is sufficient to guarantee the development and maintenance of competence ($M = 2.08$, $SD = .65$). Indeed, there is also agreement ($M = 3.30$, $SD = .59$) that after leaving university, engineers and earth scientists must pursue their professional development through formal and informal continuing professional development. With respect to the other statements in Question 14, there does not appear to be strong reactions to these statements. These statements tend to have mean scores clustered reasonably close.

<u>University Preservice Education and the Member-In-Training Process</u>

Questions 17 and 18 of the survey inquired into the effectiveness of the respondents' university education and the APEGGA Member-In-Training process as vehicles for preparing for the ongoing learning required for engineering and earth science practice. Response categories were 1 (*not effective*), 2 (*somewhat effective*), 3 (*effective*), and 4 (*very effective*); results are presented in Table 4.17. Respondents were also invited to offer explanatory comments in an open-ended *comments* section. For Question 17, 25 comments were offered and for Question 18, 13 comments were made. These comments were thematically analyzed and are discussed below.

Table 4.17: Effectiveness of University and Member-In-Training

	University Education (n = 156)		Member-In-Training (n = 118)	
Effectiveness	**Frequency**	**% of Respondents**	**Frequency**	**% of Respondents**
Very Effective (4)	29	18.6	8	6.8
Effective (3)	73	46.8	18	15.3
SomewhatEffective (2)	48	30.8	42	35.6
Not Effective (1)	6	3.8	50	42.4

Note. Mean = 2.80 SD = .78 Mean = 1.86 SD = .91

All 156 respondents replied to Question 17, whereas only 118 (75.6%) replied to Question 18. The lower response rate to Question 18 is explained by two factors. Presently there is no requirement for geologists and geophysicists to participate in the Member-In-Training process, therefore, Question 18 applied only to respondents who are Professional Engineers. A second explanation for the lower response rate is that some respondents obtained their professional status in another province and did not participate in APEGGA's Member-In-Training process.

Regarding the effectiveness of university preservice education in preparing practitioners for the ongoing learning requirements of professional practice, 102 (65.4%) respondents reported their university education was effective or very effective. The mean score to the question was 2.80 and the standard deviation was .78.

The 25 comments related to the effectiveness of university education were clustered into three themes. By far, the dominant theme was the role of university education in preparing practitioners how to learn. These comments were characterized well by two respondents who noted, "my university training gave me a sound technical base to begin my engineering career, taught me proper scientific problem solving techniques and helped me learn to work effectively when under pressure," and "learning to learn was an important aspect of university education."

Notwithstanding these comments on the intrinsic value of university education in facilitating the development of learning skills, an older respondent highlighted "when I was in university ongoing learning was not a relevant topic, thus it failed to prepare us for today's reality. How can we better prepare today's students for what they will face 20 years from now?" This response, echoed in other comments throughout the study, suggests that there may be some differentiation in the experiences of respondents based on characteristics such as age and work experience.

The second theme that emerged from the *comments* section related to the effectiveness of university education and focused on foundational content knowledge. Many suggested that university education was too theoretical "with very poor emphasis on the real world." This theme should be interpreted carefully as much university education focuses on the development of declarative knowledge instead of procedural knowledge. As Cervero (1992) highlighted, declarative knowledge is a necessary antecedent for the development of procedural knowledge. What appears to happen, though, is that as procedural knowledge is developed declarative knowledge is internalized with the effect of becoming second nature or even apparently forgotten. It is possible that the attack on university education being "too theoretical" lies in the fact that the relationship between the development of declarative and procedural knowledge may be poorly understood.

A third theme which emerged was that university education focused too heavily on the technical dimensions of engineering to the detriment of other important content areas APEGGA professional members use in their careers such as management. As one respondent noted, "most engineers do not end up working in technical design positions, but most undergraduate courses concentrate on these areas." Another respondent indicated that more course content was needed in "finance, international business, and law."

On Question 18, which was related to the APEGGA Member-In-Training process, 92 (58.9%) of total respondents indicated that the process was not effective or only somewhat effective in preparing engineers for the ongoing learning requirements of professional practice. The scale used for this question was the same as for Question 17. Most of the 13 comments were quite hostile in nature and echoed frustration over the time, energy, and money related to the process versus the accrued benefits.

Constructive comments about the Member-In-Training process were highlighted by a few respondents. One respondent noted that "the program had little effect on my training or outlook on continued training. At that time (1985) it was more of a formality than anything else. I believe a mentor program is a step in the right direction." Another respondent indicated that APEGGA "should implement a required, structured E.I.T. [Engineer-in-Training] program." It was also noted that the effectiveness of the Member-In-Training process was very dependent on the employer and the level of responsibility that engineers were given during this induction stage of their careers.

Formal Continuing Professional Development

The final part of the data analyses for the third research question on factors which influence learning in professional engineering and earth science practice relate to formal continuing professional development. Several data were collected related to formal continuing professional development (CPD). The nature of data collected involved previous formal CPD respondents had undertaken, influences on participation in formal continuing professional development, the degree of employer support for such activities, and the type of formal recognition preferred.

Question 3 inquired into the nature of previous formal continuing professional development. This question was posed to ascertain the nature of formal programming, if any, in which respondents had participated. Ten discrete subject-matter areas were identified for respondents and an eleventh *Other* category was provided. The results from this question are detailed in Table 4.18.

For 110 (71.4%) respondents, most of their previous formal CPD was reported to be in their branch of engineering or earth science. Management, administration, and related activities ranked as the second most common form of formal CPD and was reported by 79 (51.3%) respondents.

Table 4.18 Previous Formal Continuing Professional Development

Previous Formal CPD	# of Times Reported	% of Total Respondents
Your branch of engineering or earth science	110	71.4
Management, administration, or related	79	51.3
Technically oriented computer technologies	38	24.7
Another branch of engineering or earth science	32	20.8
Environmental technologies	28	18.2
Accounting, finance, costing, cost control, etc	27	17.5
Personnel, industrial relations, and related	23	14.9
Quality control (e.g, TQM, ISO 9000)	23	14.9
Law and related	14	9.1
General culture and/or humanities	11	7.1
Other	6	3.9

Technically oriented computer technologies ranked third by 38 (24.7%) respondents and formal CPD in another branch of engineering or earth science was the fourth most commonly mentioned item identified by 32 (20.8%) respondents. Six *Other* items were listed by respondents and included formal continuing professional development activities in personal relations, process control, personal computer skills, foreign languages, real estate, and economics.

Question 7 inquired into the reasons respondents participated in company-sponsored, formal continuing professional development. The researcher was curious to identify factors which might confound a respondents choice and participation in workplace sponsored continuing professional development activities. A four-point

Likert scale was used to score the question. The scale anchors ranged from 1 (*not important*) to 4 (*very important*). The results are outlined in Table 4.19.

Table 4.19 Influences on Company-sponsored, Formal CPD
(n =150)

Influence	NI	SI	I	VI	Mean	SD
It directly assists you in your work	4	12	43	91	3.47	.76
It leads to career advancement/promotion	28	37	43	42	2.66	1.08
It is required by your supervisor/department	32	47	39	32	2.47	1.05
It is expected by your supervisor/department	37	53	42	18	2.27	.97
Networking with colleagues	42	59	42	7	2.09	.86

The reason cited as being the most important influence in company-sponsored formal CPD was that it assists directly in a engineer or earth scientist's work (M = 3.47, SD = .76). The next reason cited as an influence was participation in company-sponsored CPD leads to career advancement and promotion (M = 2.66, SD = 1.08). The possibility that formal CPD might be required (M = 2.47, SD = 1.05) or expected (M = 2.27, SD = .97) by a supervisor or department ranked third and fourth respectively. Using formal CPD as an opportunity to get away from work and learn what other colleagues are doing (M = 2.09, SD = .86) ranked as the least important reason for participating in company-sponsored, formal continuing professional development. It appears, then, that the utility of development activities are the most important reason for participation in company-sponsored, formal continuing professional development relative to the items cited in Question 7.

Question 19 of the study asked respondents to rate how supportive their employers were of formal CPD. The choices respondents had for the first part of the question were 1 (*not supportive*), 2 (*somewhat supportive*), 3 (*supportive*), and 4 (*very supportive*). The results are presented in Table 4.20.

Table 4.20: Employer Support for Formal Continuing Professional

(*n* =143)

Degree of Employer Support	Frequency (*n* =)	% of Respondents
Very supportive	19	13.3
Suppcrtive	48	33.6
Somewhat supportive	50	35.0
Not supportive	26	18.2

Note. Mean score = 2.58 SD = .88

Some respondents explicitly opted out of this question by stating in the *comments* section that they were self-employed and felt the question did not apply. The degree of employer support was rated by respondents (*n* = 143) was: 19 (13.3%) as very supportive, 48 (33.6%) supportive, 50 (35.0%) somewhat supportive, and 26 (18.2%) not supportive. Fifteen comments were offered to this question and were generally made to reinforce a choice identifed as *somewhat supportive* or *not supportive*.

The nature of comments offered reinforced the notion that structural changes in the nature of engineering and earth science professional work environments were having an impact on professional development activities. One respondent noted " I am working on a contract and am expected to know what I need to do the job.

Otherwise, I am expected to get training with my own initiative and at my own expense" and " as one of two engineers in a small company there is no time and costs of course is prohibitive." Yet another respondent indicated that "extensive downsizing in industry has resulted in less time, less opportunity, and burn out."

The kind of recognition for participating in formal CPD that respondents preferred was investigated in Question 9 of the survey. The results of this question are presented in Table 4.21 according to the frequency distribution.

Formal recognition was reported as not important to 78 (50.3%) respondents. A certificate of completion was indicated as a preferred form of recognition by 32 (20.6%) respondents, credit towards an advanced university degree was identified by 25 (16.1%) respondents, credit towards an APEGGA sponsored program by 10 (6.5%), and credit towards a technical society sponsored program by 4 (2.6%) respondents.

Table 4.21: Recognition for Formal Continuing Professional Development (*n* =155)

Formal Recognition Preferred	Frequency (*n* =)	% of Respondents
Formal recognition not important	78	50.3
Certificate of completion	32	20.6
Credit towards an advanced university degree	25	16.1
Credit towards an APEGGA sponsored program	10	6.5
Credit towards a tech. society sponsored program	4	2.6
Other	5	3.2

Five additional suggestions were offered in the *Other* section of Question 9. These included a statement that no formal recognition should be forthcoming for participation in formal continuing professional development. Other comments included monetary reward, professional advancement, recognition for a combination of credit/non-credit activities, and a certificate of completion indicating that a group of development activities had been completed.

General influences on participation in formal continuing professional development were incorporated in Question 8 of the survey and presented in Table 4.22. A four-point Likert scale which ranged from 1 (*not important*) to 4 (*very important*) was used to score 23 discrete variables for this question. A twenty-forth open-ended *Other* section was used to capture any items that might have been missing from the list.

A course or program being relevant to a practitioner's needs was ranked as the most important influence on participation ($M = 3.50$, $SD = .69$). A personal desire to learn ($M = 3.40$, $SD = .69$), the credibility of sponsors or presenters ($M = 3.18$, $SD = .82$), and sufficient information about the course content ($M = 3.14$, $SD = .74$), were also reasons which ranked high as influencing participation.

Negative experiences with prior learning (M = 1.73, SD = .91), professional burnout (M = 1.76, SD = .85), sufficient recognition for participation in learning (M = 1.91, SD = .83), and low personal priority in relation to other activities (M = 1.94, SD = .83), were cited as the least important influences on participation in formal CPD for engineers and earth scientists in the sample.

Four additional comments were made in the *Other* section of Question 8. These other influences on participation included the cost to the company, the cost to the individual, the opportunity to network, and professional duty.

Table 4.22: Influences on Participation in Formal CPD

(*n* = 152)

Influence	NI	SI	I	VI	Mean	SD
Courses/program relevant to my needs	2	11	49	91	3.50	.69
Personal desire to learn	2	12	62	77	3.40	.69
Credibility of sponsors or presenters	8	16	70	59	3.18	.82
Sufficient Information about course content	6	15	84	48	3.14	.74
Professional/work contraints (relief, time off)	10	33	59	51	2.99	.90
Personal time constraints	10	37	65	42	2.90	.88
Convenient time	12	37	71	33	2.82	.86
Sufficient info. about learning opportunities	8	40	83	21	2.77	.75
Meet/interact/exchange ideas with others	12	52	55	34	2.73	.90
Convenient location	18	45	66	24	2.63	.89
Affordable learning opportunities	17	56	58	22	2.56	.87
Learning activities that match learning style	17	58	60	17	2.51	.84
Program registration costs paid by employer	30	54	40	28	2.43	1.00
Professional advancement w/possible financial	32	52	42	27	2.42	1.01
Enjoyment due to change in routine	27	57	48	21	2.41	.94
Activity recommended by colleague	24	64	59	6	2.31	.78
Fear of professional obsolescence	35	63	43	12	2.21	.89
Sufficient confidence in your learning ability	55	39	44	13	2.10	1.00
Encouragement through external source	47	62	36	8	2.03	.87
Low personal priority in relation to other activities	47	67	21	9	1.94	.85
Sufficient recognition for participating in learning	55	59	34	4	1.91	.83
Professional burnout	68	51	21	6	1.76	.85
Negative experiences with prior learning	82	37	27	7	1.73	.91

The third research question in this study focused on identifying some factors that influence learning in professional engineering and earth science practice in Alberta. The reasons the respondents sought new information were identified. The effectiveness of a range of learning activities, as rated by respondents, was examined. A review of content areas where respondents perceived a need for structured approaches in assisting their learning was presented.

A comparative analysis related to mandatory continuing professional education was also undertaken. This included an examination of the reasons given for not supporting and supporting a mandatory continuing education requirement for APEGGA professional members.

The effectiveness of university preservice education and APEGGA's Member-in-Training process in preparing practitioners for the ongoing requirements of professional practice was also examined. The attitudes towards a number of statements about continuing professional development was presented along with an analysis of factors related to past formal continuing professional development in which respondents had engaged.

Emerging Continuing Professional Development Needs

Three open-ended questions were posed at the end of the survey, appearing in Section IV. These questions were intended to enable respondents to share their viewpoints and opinions on the emerging continuing professional development needs of APEGGA members. The comments were examined to discover the frequency of responses and common themes. The data analyses are presented below according to the questions as they appeared in the survey.

Most Pressing Professional Development Needs

This question asked respondents to comment on the most pressing professional development needs of engineers and earth scientists today. A total of 177 discrete comments were made by 110 (71.4%) respondents. Comments are organized for this section according to identifiable skills and knowledge required for contemporary professional practice, the nature of the professional work environment, and required learning resources. The single disrete, dominant theme of this question, which was noted 22 times, focused on the need for engineers and earth scientists to remain technically current and up-to-date as the most pressing professional development need. Only four respondents indicated there were no pressing professional development needs.

For comments related directly to the skills and knowledge that practitioners need today, an umbrella category was developed, into which 62 comments were classified. Interpersonal communications (15) and computer technologies (10) were cited most frequently by respondents as areas where skills and knowledge were pressing. Complex project management, critical thinking, learning to manage information, utilizing technical resources, as well as learning how to learn and adapt were other themes that emerged as pressing professional development needs directly related to a practitioner's skill set and knowledge base.

On matters related to the professional work environment, 39 comments were made. Among these items were comments about the need for better development and utilization of multidisciplinary teams, employers who were more supportive towards learning, needs-based technical training, stable work environments, and challenging work assignments.

Comments which could be broadly classified as related to learning resources totaled 49. The most common theme in this area was the need for formal courses and informal learning resources relating to environmental protection (14). Other content areas identified by respondents included computers, finance and accounting, safety, cost control and quality management.

Improvements for Facilitating Continuing Professional Development

The second open-ended question asked respondents to identify areas for improvement in facilitating continuing professional development for engineers and earth scientists. A total of 119 discrete comments were made by 98 (63.6%) respondents. Of this number, ten respondents explicitly noted they were not sure about improvements or felt that no improvements were necessary. Comments were made which could generally be organized around professional work environment, formal educational programming and informal learning resource themes.

In the area of the professional work environment 27 comments were made. Employer support in the form of adequate time and financing was listed 17 times and emerged as the dominant theme in this area. Challenging work assignments, research facilities, and development strategies were also themes in this area.

Comments in the area of formal educational programming tended to focus on the format of programs. The emphasis of the 53 comments made in this area was to improve programming to make it more convenient and flexible for users. To this end, short practical course formats were identified 15 times. University evening seminars, industry information exchanges and APEGGA sponsored programs were also identified as areas where formal programming could be improved. Several comments were also made about the need for better dissemination of information on available professional development opportunities for APEGGA members.

Improvements to learning resources were made by 13 respondents. The comments tended to focus on the easy availability of resources. These nature of items in this area included the need to develop Internet-based practical resources, technical bulletins, technical libraries, and self-directed learning resources.

Support in Pursuing Professional Development Activities

The final open-ended question asked respondents to identify the kinds of support required to assist engineers and earth scientists in pursuing professional development activities. There were 122 discrete comments made on this question by 103 (66.0%) respondents. These comments focused on themes related to the professional work environment, programming and learning resources, and an expanded APEGGA role in professional development. Only seven respondents explicitly indicated they were not sure, or that there was no need for support in pursuing professional development activities.

The professional work environment encompassed 75 comments. Employer support in the form of adequate time (18) and money (22) was identified. An additional 18 respondents indicated overall support was necessary from employers. Other comments related to the need for better communication with peers, clearly articulated professional development strategies, mentors, and in-house programs.

Educational programming which was accessible by way of flexible times, affordable costs, and convenient locations were identified. This area also included comments about the need to ensure that information was effectively disseminated so that members were aware of available programs.

A greater role for APEGGA in facilitating professional development was also identified by respondents. Some suggestions included an information clearinghouse function of available programs. An advocacy and educational role was also cited as one way APEGGA could assist in improving the kinds of support that are available from employers for members seeking professional development opportunities.

Summary

This chapter presented the general results of data analyses that were carried out for this study. The findings were organized and presented in tabular format according to the three research questions which guided this study. The quantitative data for this study were summarized and reported by frequency, percentage distribution, and measures of central tendency and variability. The qualitative data from the open-ended questions were organized and presented thematically.

The findings support the notion that professional engineers and earth scientists in Alberta do use a variety of formal and informal learning activities to develop and maintain professional competence. In fact, activities which could be categorized as informal learning activities constituted the top ranked activities in the survey which were reported to be used to develop and maintain professional competence. It was also discovered that professional work environments which facilitate informal learning were also important to professionals being able to conduct their work effectively.

CHAPTER V

DISCUSSION OF FINDINGS, IMPLICATIONS, AND CONCLUSION

Chapter Five contains three sections. The first section is a summary and discussion of the findings presented in Chapter VI; the second section outlines implications for public policy in the area of continuing professional development and educational practice; and the last section highlights suggestions for further research.

Summary and Discussion of the Findings

In this section, the findings are summarized and discussed according to the three research questions that guided the study. These questions were:

1. Which learning activities do professional engineers and earth scientists find important for developing and maintaining competence?
2. What professional work environment conditions do engineers and earth scientists find important in developing and maintaining competence?
3. What factors influence learning in professional engineering and earth science practice?

The purpose of this section is to integrate the findings presented in Chapter VI with the conceptual framework and literature presented in Chapters I and II.

A descriptive survey, administered by mail in December 1995, was used to gather data from a proportional stratified sample of 399 APEGGA professional members. The data collection process generated 156 usuable responses for a 39.1% response rate. The questionnaire's provided quantitative data which were analyzed using SPSS for Windows. Qualitative data were analyzed according to frequencies for emerging themes.

Learning Activities Used For Professional Competence

The summary and discussion in this section focuses on the findings related to the first research question. Within the conceptual framework that guided this study it was suggested that professional engineers and earth scientists most likely draw upon a range of formal and informal learning activities to develop and maintain competent professional performance. The researcher developed a typology for classifying formal and informal learning activities based on the work of Belsheim (1986), Day and Baskett (1982), Marsick and Watkins (1990), and Schön (1983).

The typology was organized around four types of activities. The first category was labeled *action-in-practice*. This category involved *informal* activities inherent in the nature of a job assignment. This would be on dimension of what has become known as "on-the-job learning." The next category, also referred to as "learning on the job," involved informal activities of a consultative nature and was split into two sub-sections. The first sub-section related to activities which involved deliberate consultation with another person considered an authority related to the subject of consultation. The second sub-section related to activities where consultative activities occurred by use of print or non-human resources. A category of informal activities called *other* was introduced to capture those items which could not be easily categorized in the *action-in-practice* and *consultative* categories. Activities related to educational programming were categorized as *formal* learning activities.

Consistent with the conceptual framework proposed in Chapter I, the purpose of this typology was to develop an identification method which could then be used to assess how and where learning occurred in professional engineering and earth science practice. A primary goal of this process was to understand how learning associated with competent professional performance could be better facilitated by stakeholders. The researcher advocated an approach to continuing professional development which was concerned with the quality of performance (Houle, 1983) in professional practice, hence understanding how and where respondents engaged in performance-oriented learning was of paramount interest in this study.

To operationalize the first research question, an list of learning activities thought to be associated with professional competence was developed. These items were primarily developed according to previous work done with engineering populations in the United States by Cervero, et al. (1986) and Jones and LeBold (1987). An open-ended component was added to Questions 5 and 6 of the questionnaire to capture items that might have otherwise been missed. The inventories were organized in two parts. The first part focused on activities used to develop and maintain technical competence. The second part of the inventory presented activities used to develop and maintain managerial competence.

According to the findings, the items ranked as most important for developing and maintaining technical competence were informal in nature and fell into the *action-in-practice* category. These involved practitioners drawing on their own personal skill and knowledge, job assignments that constantly challenged overall technical competence, informal contact with coworkers, and working with a team to make decisions about a project. Other activities ranked as important in this area involved receiving advice from a supervisor or coworker and experimenting with different approaches to a problem. Similarly, drawing on personal skill and knowledge, informal contact with colleagues at work, and consulting with internal experts were reported as the most important activities for developing and maintaining managerial competence.

The findings from the first research question tend to support the ideas that Cervero (1992) advanced about the value practitioners tend to place on procedural knowledge generated in practice. Drawing on personal skill and knowledge was ranked as the top activity used to develop and maintain both technical and managerial competence. These findings also tend to support the arguements advanced by Nowlen (1988) and Schön (1983, 1987) that practitioners are also legitimate sources of practice related knowledge.

It also appears the activities used to develop and maintain competent professional performance are multifaceted. The most important activities reported by respondents in this study are informal in nature and are found in the professional work environment. This finding is consistent with what Marsick and Watkins (1990) found in their work on informal and incidental learning in the workplace. These researchers reported that 83% of the learning in the industrial organizations they studied could be classified as informal or incidental. It is also important to note respondents in the present study ranked a range of formal and informal activities as reasonably important in developing and maintaining competence. This has several implications.

First, these findings highlight Day and Baskett's (1982) as well as Nowlen's (1988) arguement that dominant reliance on established human resources development and continuing professional education strategies, as manifested through the programming model, is not a singularly suitable response to facilitating competent professional performance. Over the last several decades human resources development and continuing professional education have been seen by many stakeholders as the key tools for ongoing development, primarily through updating strategies (Dubin, 1990, Nowlen, 1988). It may be more appropriate to view development interventions grounded in the programming model paradigm, as one component of available resources which can be used to achieve competent professional performance. Continuing professional education and human resources development must not, then, be seen as the sole resource for performance related challenges in the workplace. To continue down such a path will likely result in a further erosion of the credibility of those responsible for the development and implementation of educational interventions for professionals (Aherne and Barron, 1996).

A second implication of the findings to the first research question is that more attention must be paid to how neophyte professionals are prepared for the ongoing learning requirements of modern professional practice (Houle, et al., 1987; Margetson, 1994). More attention and emphasis must be placed on individual career management and ongoing learning skills (Baumann, Duncan, Forrer, and Leibowitz, 1996; Farquhar and Longair, 1996). This is highlighted by respondents reporting the need to draw on personal skill and knowledge (Schön, 1987) and job assignments that constantly challenge overall technical competence as important to competent professional performance. This suggests individual practitioners develop skills in identifying existing and potential skill deficiencies (Aherne and Nowicki, 1995). It also suggests a more active advocacy role for individuals to seek out assignments in which they can continue to seek new professional challenges and vitality (Miller, 1990).

The findings further suggest there is a role for reflection-in-action, reflection-on-action, and knowing-in-action (Schön, 1983). Drawing on personal skill and knowledge, as reported in the findings of the first research question, involves elements of these three concepts. Yet, in the modern workplace it seems that there is little time for reflection. In fact, the action focused and utilitarian nature of North American society often works against creating legitimate opportunities for reflection (Fullan, 1993; Handy, 1989). Clearly this creates a paradox. Drawing on personal skill and knowledge as well as informal contact with coworkers was reported as important to competent professional performance, however, there generally tends to be little social and organizational permission to do so. Any available time is often seen to be wasted if it is not consumed by action. In this way, time is seen generally as a commodity to be expensed rather than as an asset to be wisely invested. Taking the monetary analogy to another level, there may be merit in reconceptualizing time as an asset to be both invested wisely in reflection and expensed as necessary for effective action. A greater emphasis on opportunities and skills in effective reflection, where practitioners make judgements about suitable time for effective reflection, may be seem somewhat idealistic, but is arguably a necessary antecedent for effective practice in the emerging professional work environment.

A third implication of the first research question is that effective consultation skills are important to developing and maintaining competence. This suggests that in the development of professional skill sets, greater emphasis is placed on having neophyte engineers and earth scientists learn how to effectively consult (Houle, et al., 1987). Knowing where to find and access a range of information for setting and solving professional problems is emerging as one of the keys to competent professional performance (Davenport and Cronin, 1994; Miller, 1994).

A fourth implication of the findings to this research question involves the need for greater attention to the opportunities for informal contact with coworkers and working in teams (Marsick and Watkins, 1990; Watkins and Marsick, 1992). Informal contact with coworkers ranked as the third most important activity in the study for developing technical competence and the second most important for managerial competence. In many contemporary organizational settings there is a sense that available time for informal socializing is an unaffordable luxury as more emphasis is placed on maximizing productivity and achieving results. The results of this survey suggest that informal contact is important for competent professional performance.

Ultimately, the findings from this question highlight the need for a broader conception of the processes used to develop and maintain competent professional performance (Belsheim, 1986; Day and Baskett, 1982; Nowlen, 1988). This will involve a conceptual shift, particularly among employers, professional associations, and educational programmers, in they ways they facilitate competent professional performance. This view is certainly consistent with what Houle (1983) noted as a concern with the quality of professional performance as the next evolutionary step in the field of continuing professional education.

Professional Work Environment Conditions

This section outlines a summary and discussion of the findings from the second research question. This question involved an examination of the professional work environment conditions engineers and earth scientists find important for maintaining professional competence. The results from the second research question illustrate that respondents reported sufficient time and opportunity to communicate internally with coworkers as the most important work environment factor in the study for conducting work effectively. Sufficient support from technical personnel as well as up-to-date computer equipment and facilitates also ranked from 3 (*important*) to 4 (*very important*) for conducting work effectively on the scale used for this question in the study. It was further revealed that nearly half of the respondents in this study were experiencing an increase in complex engineering and earth science problems to which there were no easy solutions. Nearly half of the respondents indicated they had experienced an unmet need for information, skills, and knowledge between one and three times in the last three months.

There is clearly a relationship between the importance placed on informal contact with coworkers as well as other forms of consultation and the importance placed on having sufficient time and opportunity to communicate internally with coworkers. A limitation of this study was that it did not ask respondents if they indeed had sufficient time and opportunity to communicate internally with coworkers. The survey shows a normative response from respondents to this issue, but not a descriptive snapshot of their present reality. Notwithstanding this limitation, the results from the *Structural Change and Professional Practice* study commissioned by APEGGA illustrate the impact of emerging pressures in the workplace and the resulting impact on professional practice. In the structural change study respondents indicated they were most concerned with the availability of time and resources for training and education as well as time to do a thorough, professional job (APEGGA, April, 1995).

Addressing the nature of the modern workplace, then, will likely become a pressing issue for APEGGA, practitioners, and employers. Unlike medicine or law, professional engineers and earth scientists are one of the few self-governing professions where the practice relationship is dependent on corporate employee-employer relationships. This creates interesting challenges to the nature of professional autonomy. This may not have been as much of pressing concern in the past when a reasonably stable work environment characterized the nature of post

World War II North America, but it is clearly a more pressing issue as concerns about greater volatility and competition in engineering and resource businesses emerge. It appears matters related to deprofessionalization in engineering and earth science are becoming more prevalent and will require greater consideration by stakeholders as they relate to creating a sustainable workplace climate for competent professional performance.

The findings from the second research question also highlight sociopolitical concerns related to the physical environment and public safety emerging as prominent themes engineers and earth scientists must continue to effectively address. Professional practice in these areas appears to be further compounded by the fact that cost control pressures and more stringent regulatory regimes make planning and executing projects much more complex in contemporary practice. For example one geologist noted "in many areas the land and legal considerations seem to affect the design of a drilling program more than the geology."

Another theme arising out data related to the second research question involves the use of computers and new technology in engineering and earth science practice. In this area there also appears to be a paradox. Computer technology makes it easier to do much of the more mundane technical tasks such as design drawings and computer mapping; however, there are two effects. A meaningful comment in the study by one respondent cuts to the essence of what other respondents alluded to. This was that computer-based technologies often introduce new levels of complexity which in turn invite more sophisticated engineering and earth science interventions.

As the volume of information and the power of the technological tools available to practitioners increases, it appears there will be a greater need to develop a range of transferable personal information management skills which can be used to make informed decisions about the use of technology in the effective development and implementation of engineering and earth science projects. This message was also echoed throughout some of the other open-ended comments in the study.

The nature of complex engineering and earth science problems to which there are no easy solutions coupled with a need for information, knowledge, or skills highlights one of the elements of the conceptual framework which guided this study (Schön, 1983, 1987). This is the suggestion that as engineers and earth scientists face problems in practice which are unique and ambiguous, they tend to rely on informal means of learning to achieve practice outcomes. Although it was beyond the scope of this study to clearly delineate a relationship between complex professional practice problems and informal learning, the high ranking in this study of informal activities used to develop and maintain competence suggest there is some foundation to the concept. Useful knowledge generated in practice and considered highly valuable by practitioners, then, supports the critique that Nowlen (1988) and Schön (1983) advanced about the over reliance on knowledge based in the technical rational tradition. This notion invites a reconsideration about the legitimate balance between declarative and procedural knowledge in professional practice (Cervero, 1992).

Consistent with the idea that practitioners generate knowledge useful for practice (Cervero, 1992; Nowlen, 1988; Schön, 1983), is the finding that some 80%

of respondents believe the professional member has a substantial individual responsibility for maintaining competence. Engineers and earth scientists are involved actors in their professional work environment who generally have a well developed sense of professional mission. Nevertheless, the professional work environment is becoming more demanding (Curry, et al., 1993; Handy, 1989, 1994). It creates unprecedented challenges for maintaining competent professional performance (Matthias, 1991; Sanford, 1989). This is evidenced by the recent study on structural change commissioned by APEGGA (APEGGA, 1995, April) as well as by the Association of Consulting Engineers of Canada's study (ACEC, 1994, November) on human resources in the consulting engineering industry.

The notion of change in the contemporary professional work environment for engineers and earth scientists, as reflected in the APEGGA and ACEC studies, highlights the relevance of Fox, et al.'s (1989) typology of change in professional practice. Clearly engineers and earth scientists appear to be experiencing an increase in redirections and transformational change which has the potential to influence their ability to maintain competent professional performance. This concept is substantiated through the responses to the open-ended comments in this study. Employer support, in the form of adequate time and money, as well as overall support is seen as a pressing issue for many respondents in this study. Many of the issues related to the professional work environment are being fueled by rapid structural changes in the economic nature of industries, technological change, growing expectations for due diligence in managing the physical environment, and concern over public safety.

Consistent with Nowlen's (1988) performance model of continuing professional education, it appears that competent professional performance in engineering and earth science is largely a function of a practitioner's interaction with the professional work environment. This being the case, stakeholders interested in professional learning and change are advised that the scope of effective continuing development must consider the context within which an engineer or earth scientist practices. This implies a need to move to approaches of continuing professional development which transcend those embodied in the education or programming models.

Factors Influencing Professional Learning

This section highlights a summary and discussion of findings from the third research question. It was reported that respondents seek out new information primarily to acquire new knowledge, update existing knowledge, acquire new skills, and to keep abreast of new advances for general information. These reasons are performance oriented and consistent with other findings in the study related to the activities respondents report using to develop and maintain competence.

It is again worth restating that the ranking of a range of formal and informal learning activities also highlighted the premium that professional engineers and earth scientists place on informal, practice-based learning. Practice in an engineering, geological, or geophysical job as well as discussion with knowledgeable people were seen as the most effective learning activities. These findings are again consistent with Schön's (1983) concepts of knowing-in-action and reflection-in-action. The findings suggest important professional learning occurs within the context of practice. Therefore, the nature of a job itself appears to be an important factor for practice-based learning which supports competent professional performance.

When asked about structured approaches to learning, respondents generally ranked the items on this question less important than other related questions in the survey. This indicates there may be relatively less value placed on the need for structure in learning, as practice-based learning appears to be considered relatively more important to competent professional performance. Nevertheless, respondents indicated that structured learning approaches in their branch of engineering and earth science, along with content on management, accounting, and environmental technologies, were (3) *somewhat important* to (4) *important*. For the purposes of this study, structured approaches to learning did not equate to formal educational programming. It is conceivable then, that learning resources could be delivered in forms which facilitate self-directed learning, such as interactive media and small group learning situations.

Regarding mandatory continuing professional education, the majority of respondents (65.4%) were opposed. Reasons most often cited for not mandating CPE included that members keep current to maintain their job or remain competitive and that APEGGA members remain voluntarily competent as a matter of professional pride. While the researcher has highlighted the argument against mandating CPE in Chapter II, the reasons cited by respondents for not mandating CPE appear to be somewhat problematic when considered within the context of a changing professional work environment.

Based on the findings of the structural change (APEGGA, 1995, April) study and the human resources study (ACEC, 1994, November) it appears that individual concern over remaining competitive and professional pride are not sufficient attitudinal resources for maintaining professional competence. A broad range of skills are increasingly required for maintaining competence (Curry, et al., 1993). Chief among these appear to be opportunities for learning within the professional work environment. So while mandatory CPE might not be the most appropriate response to ensuring competence for APEGGA members, the reasons cited by respondents for not requiring mandatory continuing education also tend to be inconsistent with emerging challenges for competent professional performance.

The findings from the third research question also highlight a range of positive, enlightened views towards continuing professional development. Respondents strongly agree that a variety of challenging job assignments helps improve engineering and earth science skill and knowledge. Respondents also agree they must pursue formal and informal professional development upon completing university. This suggests a positive attitude towards continuing professional development among respondents.

Implications for Public Policy and Educational Practice

In this section, the implications of the study are examined as they relate to public policy and educational practice. Suggestions are made as to how continuing professional development might be more effectively facilitated amongst a range of stakeholders. The implications are of particular interest to the Association of Professional Engineers, Geologists, and Geophysicists, to continuing professional education programmers, and to human resource development specialists. The implications for practice are categorized in two sections. The first is related to public policy. The primary audience for this section are legislators and professional associations charged with legislative responsibility for administering professional legislation.

Implications for Public Policy

The following implications for public policy are based on the findings and the conclusions of this study.

1. Governments and professional associations should consider a broader definition of available mechanisms which can be used to ensure accountability for competent professional performance. The efficacy of mandatory continuing education and its links to competent professional performance are highly suspect (Cervero, 1988; Rockhill, 1983; Sanford, 1989). The findings from this study support this assertion. Mandatory continuing education as a primary mechanism for ensuring accountability for professional competence tends to miss a domain of informal learning which has been reported in this study as important for competent professional performance. Therefore, legislative initiatives which incorporate a more comprehensive approach to continuing competence and continuing professional

development should be advocated if the public policy goal is accountability for competent professional performance.

2. Professional associations should consider strategies for educating their membership and their membership's employers about the nature of performance-oriented, continuing professional development. The paradigm of the educational programming model is deeply entrenched as the dominant approach to continuing professional development (Day and Baskett, 1982; Nowlen, 1988). The findings of this study inidicate that facilitating effective continuing professional development involves creating sufficient time and opportunity for informal dialogue and connection in the workplace. An explicit awareness of the performance-oriented, learning potential inherent in on-the-job assignments which constantly challenge a range of skills and competencies is also important. This is a particularly important point as the nature of structural changes in many professional work environments have created a situation which appears to be much more hostile in recent times. The full effects of corporate and industrial restructuring have yet to be fully felt for its long-term impact on the capacity for practitioners to be able to sustain competent professional performance.

A professional association, such as APEGGA, can be viewed as discharging a responsibility for globally managing the engineering and earth science resource within its jurisdiction through an advocacy and communicative function which informs members and employers about the range of activities required to maintain competent professional performance. Such a function may prove particularly useful in engineering and earth science where there is an inherent friction in the nature of professional autonomy as professionals are often employed by an organization rather than engaged as sole independent practitioners.

3. Professional associations should consider developing guidelines and resources that enable their members to track the professional learning they do which is related to competent professional performance. A continuing competence program, such as the MOCOMP program of the Royal College of Physicians and Surgeons (Campbell, et al., 1995) maybe a first step in this new direction. Such new directions highlight Houle's (1983) suggestion that the next stage in the evolution of continuing professional education would be concerned with, and focus on the quality of professional performance.

Implications for Educational Practice

The following implications for educational practice are based on the findings and conclusions of this study:

1. Stakeholders with an interest in the quality and relevance of university preservice education should give consideration to articulating an explicit working philosophy for ongoing professional learning within the preservice university curriculum as a core element of the professional socialization process (Houle, et al., 1987). In other words, the university curriculum should have a stronger and explicit focus on developing skills which encourage neophyte practitioners to learn how to actively learn across the lifespan. While many respondents indicated their university preservice experience enabled them to learn how to learn, others suggested that

university preparation did not prepare them for what in effect would be recurring transformations occurring over the course of their professional life. The nature of structural change which characterizes modern engineering and earth science practice invites the challenge of developing skills among practitioners for ongoing learning and successful transitions over the course of a career.

2. Administrative and academic leaders within universities should consider increasing the opportunities for active and problem-based learning approaches in university engineering and earth science preservice curriculum. The findings from this study suggest the most important learning related to competent professional performance is informal in nature and occurs within the context of practice. Curricula in preservice university education which models and facilitates active, problem-based learning may more effectively prepare neophyte engineers and earth scientists for the challenges of modern practice (Margetson, 1994). Such approaches to active learning could balance off the need for transmission of foundational content with the need to develop the professional skills required to be a confident, reflective practitioner (Schön, 1983).

3. Consideration should be given by those responsible for continuing professional education to integrated models of continuing professional development. Such approaches could incorporate the context of practice and the experience of practitioners more fully in the process. Examples of new models for formal continuing professional development could be based on the social change and problem-based model advanced by Belsheim (1986) as well as the performance

model proposed by Nowlen (1988). The primary goal of this shift in educational programming would be to improve the transfer of learning from formal learning settings to the primary place of practice. The ultimate objective is to enhance the efficacy of formal continuing professional development as it relates to facilitating competent professional performance.

4. Consideration should also be given to more actively incorporating practitioners in the planning and delivery of their own learning. The tradition of summative needs assessment and updating courses in continuing professional education appears to have limited utility in an time of recurring structural change. More flexible, formative needs assessment models should be developed that enable educators and practitioners to plan for learning needs on a more timely basis. Examples of this are emerging in the workplace. Self-directed teams are increasingly charged with finding the resources they need to complete projects. Models of this type of professional development are presently being termed as just-in-time development and development-on-demand.

5. Consideration should also be given to the development of high quality learning resources that professional engineers and earth scientists can access in the workplace as well as on their own time. These might include up-to-date databases, periodicals, and multi-media resources that can be used by practitioners. Thought should also be given to introducing models of small group learning where by practitioners can engage in learning as a supportive, collaborative process which is supported by the availability of high quality resources. This would serve to address

issues related to the isolationism of self-directed learning while accommodating concerns about accessibility and flexibility that many respondents in this study indicated were a problem.

6. Consideration should also be given to changing the approaches used for employee development for engineers and earth scientists in corporate environments. First of all, the definition of employee development should be broadened to include all learning activities in which individuals and teams engage to more effectively meet organizational objectives. The goal of this approach is to tie a broad range of development activities to the strategic intent of an organization. There has been emerging concern expressed by a range of stakeholders about the efficacy of traditional human resources development practice (Aherne and Barron, 1996). Human resources development interventions often appear insufficient for meeting a range of organizational issues.

One model for companies to examine in redefining continuing professional development, especially for engineers and earth scientists, has been developed by Chicago-based Amoco Corp. The basis of the company's development approach is a career management system that ensures the right people are in the right jobs at the right time. In essence, the goal of this system is to carefully balance individual skills and aspirations with business needs. Amoco's system has been developed to effectively respond to "...a rapidly changing environment, increased competition, new technologies, sophisticated customer demands, and emerging and declining markets..." (Baumann, et al., 1996, p. 79). The cornerstone of this system is individual career plans, developed within the context of a business units goals and individual interests, that lead to identifiable outcomes. Development is broadly defined and includes job enrichment, job rotation and special assignments, or moving onto other opportunities.

Suggestions for Further Research

This study was deliberately exploratory in nature. It appears to be the first systematic inquiry into learning within professional engineering and earth science in Alberta. This study uncovered many more questions deserving of further research than it answered. This is in part, inherent in the nature of an exploratory study. It serves to highlight potential research directions which have yet to be fully explored. As such, a number of suggestions for further research have been identified. Research based on these suggestions may serve to improve understanding in the area of professional learning and change.

1. A study could be undertaken to identify circumstances under which professional engineers and earth scientists find formal and informal learning useful to meet different learning objectives. While respondents in this study identified a range of learning activities useful for developing and maintaining professional competence, it is unclear what factors trigger particular learning preferences. In this sense it would be useful to know what some of the "channel factors" are which trigger particular learning (Lewin, 1951). Complex interrelationships among personal learning characteristics, contextual factors in the practice environment, and social factors need to be further explored.

2. A study, with the primary purpose of understanding how engineers and earth scientists learn and approach change, would prove very useful in the development of policies geared to facilitating the development and maintenance of competent professional performance. Such a study could be based on the methodology Fox, et al. (1989) used in their study of professional learning and change among the physician population in the United States. This would be an invaluable contribution to the knowledge base in the area of professional learning and change for technical professionals, such as engineers and earth scientists.

3. Applied research could be undertaken to understand the nature of informal mentorship and its importance to the continuity of the engineering and earth science resource in Alberta. Several comments reflected in the study indicate increasing concern about younger engineers and earth scientists having access to senior professionals as companies continue to restructure and outsource much of their engineering and earth science work. It is possible that informal systems of learning that are closely tied to the development of competent professional performance have been disrupted and possibly eliminated as a result of industry and organizational restructuring. If this is the case, alternative models to compensate for the interruption or loss of these informal systems would prove highly useful to maintaining the competitive position of Alberta engineers and earth scientists.

4. Applied and action research could be undertaken to further understand how the professional work environment can be effectively used as a professional development tool. The traditional reliance on educational interventions vis-à-vis

training and development has had the effect of casting into the shadows the potential of workplace learning. Educational research is still in its infancy in understanding the nature and power of workplace learning as well as how it can better be facilitated.

5. In depth research could be undertaken on the nature of complex engineering and earth science problems in professional practice to which there are no easy solutions. This study endeavored to establish whether respondents were experiencing an increase in complex problems as well as what the nature of those problems were. It was beyond the scope of the current study, however, to identify the exact character of complex problems as well as the strategies which are employed by practitioners to effectively address them.

Consistent with this theme, is a need to further understand the nature of information, skill, and knowledge requirements practitioners experience which are not readily met. The focus of such research could include the identification of the strategies which are reported for overcoming the information, skill, and knowledge gap. This type of research would further serve to inform practice and would be a valuable contribution to the profession.

6. Finally, a study could be undertaken with Alberta engineers and earth scientists to test Garrison's (1992, in press) framework for self-managed learning. As structural changes in the professional work environment place more responsibility on individual practitioners and teams for achieving practice outcomes, individual self-managed and small group learning will undoubtedly become a more important dimension of competent professional performance. Research which informs practice

about how to effectively facilitate this type of learning would be an important contribution. Existing models of self-directed learning (i.e., Knowles, Tough) appear to be insufficient in explaining many of the psychological and sociological dimensions of the phenomena, which apparently has much more of a social dimension to it than most contemporary discourse in adult and continuing education acknowledges.

Conclusion

This study endeavored to identify the learning activities professional engineers and earth scientists in Alberta use to achieve competent professional performance in response to changing conditions in the professional work environment. The findings reveal that practitioners use a variety of formal and informal learning strategies to achieve competent professional performance. It was also reported that factors in the professional work environment have a substantial impact on being able to conduct work effectively. It also became apparent that the nature of recurring structural change in engineering and earth science practice has important implications for practitioners who are challenged to develop and maintain competent professional performance under difficult conditions.

The findings from this study support the conceptual framework used to guide the study. Nowlen's (1988) performance model combined with Fox, et al.'s (1989) change typology provide useful conceptual references. Indeed, it appears that competent professional performance is a function of the interaction between a practitioner and his/her professional work environment. It also appears the nature of change that occurs in the professional work environment has implications for performance, particularly as it relates to practitioners being able to effectively respond to recurring structural change. Structural change involving redirection's and transformations requires much more personal energy and attention from practitioners. This is energy and attention that is often diverted from professional practice activities. Therefore, an integrated approach to continuing professional development, as proposed in the conceptual framework, would seem to be a very appropriate response if the goal is the development and maintenance of competent professional performance.

It further appears that professionals find informal learning an important resource for developing and maintaining competent professional performance. This supports the second element of the study's conceptual framework. That being, professionals value and engage in informal learning and use it to address complex problems in practice to which there are no easy solutions. These findings support Schön's (1983, 1987) concepts about the role of knowing-in-action, reflection-in-action, and reflection-on-action as important sources of valued professional knowledge. The findings also reinforce Marsick and Watkin's (1990) work on the nature of informal and incidental learning in the workplace.

The contemporary professional practice environment is characterized by profound sociopolitical, technological, and economic structural change. Strategies for continuing professional development, such as those established in the tradition of the education model of programming, are increasingly insufficient for meeting the range of emerging professional challenges practitioners encounter. The emphasis of continuing professional development must shift from updating to one of active learning for meeting complex, ambiguous, and previously unencountered professional problems. To effectively facilitate competent professional performance requires a much better understanding of the range of learning activities used by professionals. This requires a broader conception of what continuing professional development is and where it occurs.

Stakeholders including governments, professional associations, employers, and educators, in particular, must consider a broader conception of continuing professional development as they plan policies and programs geared to ensuring a competent professional cohort. As the sophistication in the nature of professional practice evolves to new levels, so too must the responses for accountability and performance reflect a necessary level of complexity commensurate with the nature of practice. This means that simplistic solutions such as legislative requirements for mandatory continuing education are no longer adequate. Broader approaches, such as an integrated approach to continuing professional development, which focuses on the actual activities and strategies used to develop and maintain competent professional performance must begin to form the foundation for effective policy making related to administering the governance of professions.

Stakeholders are also faced with fundamental new challenges in new approaches to continuing professional development. The myriad of issues related to the power and politics of continuing professional education must be addressed. These directly relate to the dominant use of the programming model as the primary means of delivering information to professionals. Stakeholders are challenged to find new models of formal continuing professional development which incorporate the practice context into the curriculum to maximize the potential for an effective transfer of learning from the classroom or computer to the workplace. Educational practitioners, in particular, would also be well advised to more carefully consider the goals and objectives of the client's they serve. In this way, programming and other learning resources may be more effectively developed and placed so that they are accessible on a demand basis consistent with the emergent problems in their clients professional work environment.

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APPENDIX A

DEFINITION LIST AND RESEARCH INSTRUMENT

Continuing Professional Development in Professional Engineering and Earth Science

Definitions Used in this Study

Continuing Professional Development: Any formal or informal activity that professionals engage in to maintain or enhance competence and performance in their professional practice.

Formal Continuing Professional Development: Also referred to as continuing education, these are structured, planned educational experiences occurring in dedicated learning settings. They would most often be described as seminars, workshops, training sessions, and formal courses.

Competence: Competence is acquired knowledge, attitudes, and skills derived through specified roles and settings and stated in terms of performance which encompasses a broad composite of behaviors.

Technical Competence: For the purposes of this questionnaire, technical competence is used to describe what might be termed technical or pure engineering and the knowledge and skill which are necessary to competently practice such engineering. The same will be true for geology and geophysics.

Managerial Competence: For the purposes of this questionnaire, managerial competence will be defined as encompassing the application of the knowledge and skill that must be carried out so that technical engineering and earth science can be performed. Examples of activities included in demonstrating managerial competence might include, but are not limited to: contracts, costing, cost-control, financing, construction, inspection, evaluations, report preparation, studies, purchasing, scheduling, human resource management, general management and project management.

Structured Approaches to Learning: For the purposes of this questionnaire, structured approaches to learning represent instructional content which is packaged in a way that makes the information timely, relevant, and easy for you to learn. The learning may take place in a formal learning setting, or it may take place informally, such as through correspondence, Internet, etc.

Continuing Professional Development in Professional Engineering and Earth Science

Your input is essential for understanding how engineers and earth scientists learn once they have completed their formal university training. This information will help the Association of Professional Engineers, Geologists, and Geophysicists of Alberta plan for your continuing professional development needs. This questionnaire will take about 25 minutes to complete. Thank you for your assistance.

Please Do Not Write In This Space
Respondent I.D.

___ ___ ___
1 2 3

Section I - Professional Learner Characteristics

1. Do you find you ***seek out new information primarily*** to:
(Indicate **(X)** in the boxes to all that apply)

- ☐ Update existing knowledge 4
- ☐ Update existing skills 5
- ☐ Acquire new knowledge 6
- ☐ Acquire new skills 7
- ☐ Reinforce that you are doing things correctly 8
- ☐ Understand how technical advances affect your field or industry 9
- ☐ Keep abreast and aware of advances for general information 10
- ☐ Other (Please Specify) ____________________________ 11

2. How important are each of the following in enabling you to conduct your work effectively?
Please use the following scale:

	Does Not Apply	Not Important	Somewhat Important	Important	Very Important	
Up-to-date technical equipment and facilities	9	1	2	3	4	12
Up-to-date computer equipment and facilities	9	1	2	3	4	13
Sufficient support from technical personnel	9	1	2	3	4	14
Sufficient support of non-technical personnel	9	1	2	3	4	15
Ready access to new technical information	9	1	2	3	4	16
Sufficient time and opportunity to communicate internally with co-workers	9	1	2	3	4	17
Sufficient time and opportunity to communicate externally with colleagues	9	1	2	3	4	18
Sufficient time and opportunity to attend professional development activities	9	1	2	3	4	19
Ongoing investment in company sponsored research and development	9	1	2	3	4	20
Career guidance	9	1	2	3	4	21
Other, (Please specify and rate)____________________	9	1	2	3	4	22

3. In which of the following ***subject areas has most*** of your ***formal continuing professional development*** focused? (Indicate **(X)** in **more than one** box if you need to)

- ☐ Your branch of engineering, geology, or geophysics 23
- ☐ Another branch of engineering, geology, or geophysics 24
- ☐ General culture and/or humanities 25
- ☐ Management, administration, or related 26
- ☐ Law and related 27
- ☐ Accounting, finance, costing, cost control, etc. 28
- ☐ Personnel, industrial relations, and related 29
- ☐ Environmental technologies 30
- ☐ Technically oriented computer technologies (CADD, computer mapping, etc.) 31
- ☐ Quality control (e.g. TQM, ISO 9000) 32
- ☐ Other, please state__________________________ 33

4. Rate your need for ***structured approaches to learning*** in the following to be:

	No Need	Some Need	Need	Highly Needed	
Your branch of engineering, geology, or geophysics	1	2	3	4	34
Another branch of engineering, geology, or geophysics	1	2	3	4	35
General culture and/or humanities	1	2	3	4	36
Management, administration, or related	1	2	3	4	37
Law and related	1	2	3	4	38
Accounting, finance, costing, cost control, etc.	1	2	3	4	39
Personnel, industrial relations, and related	1	2	3	4	40
Environmental technologies	1	2	3	4	41
Technically oriented computer technologies (e.g., CADD, computer mapping, etc.)	1	2	3	4	42
Quality control (e.g., TQM, ISO 9000)	1	2	3	4	43
Other, (please state)______________________	1	2	3	4	44

(PLEASE TURN TO THE NEXT PAGE)

5. Please rate the following activities in assisting you to develop and maintain ***technical competence*** in daily practice. Use the following scale:

	Does Not Apply	Not Important	Somewhat Important	Important	Very Important	
Attend university-sponsored credit courses	9	1	2	3	4	45
Attend workshops and seminars (technical)	9	1	2	3	4	46
Attend workshops and seminars (mgmt development)	9	1	2	3	4	47
Attend in-house courses	9	1	2	3	4	48
Complete formal self-study programs (correspondence, CAI)	9	1	2	3	4	49
Consult a dictionary of technical terminology	9	1	2	3	4	50
Consult an external technical report	9	1	2	3	4	51
Consult an internal technical report	9	1	2	3	4	52
Consult a handbook	9	1	2	3	4	53
Seek out an internal expert to explain a project report	9	1	2	3	4	54
Seek out an external expert to explain a project report	9	1	2	3	4	55
Draw on personal skill and knowledge	9	1	2	3	4	56
Experiment with different approaches to a problem	9	1	2	3	4	57
Receive advice from a supervisor or co-worker	9	1	2	3	4	58
Consult a catalogue or manufacturer's literature	9	1	2	3	4	59
Consult with a manufacturer or supplier representative	9	1	2	3	4	60
Consult videotape, software, or other electronic media	9	1	2	3	4	61
Read an engineering or earth science periodical	9	1	2	3	4	62
Refer to a technical publication	9	1	2	3	4	63
Informal contact with co-workers	9	1	2	3	4	64
Informal contact with other professional engineers or earth scientists outside your work	9	1	2	3	4	65
Rehearse some skill useful to the job	9	1	2	3	4	66
Request an assignment to a particular project for needed experience	9	1	2	3	4	67
Work with a project team to make decisions about a project	9	1	2	3	4	68
Attend a convention of professional organization	9	1	2	3	4	69
Prepare and make a technical presentation before engineering or earth science related group	9	1	2	3	4	70
Job assignments that constantly challenge overall technical competence	9	1	2	3	4	71
Job assignments that constantly challenge specific specialty areas of technical competence	9	1	2	3	4	72
Other, (Please specify and rate):____________________	9	1	2	3	4	73

6. ***If you presently work in a supervisory or managerial role***, please describe each of the following activities in assisting you to develop and maintain ***managerial competence*** in daily practice? Use the following scale: If you do not work in a supervisory or managerial role, please move directly to question 7.

	Does Not Apply	Not Important	Somewhat Important	Important	Very Important	
Attend university-sponsored credit courses	9	1	2	3	4	74
Attend workshops and seminars (technical)	9	1	2	3	4	75
Attend workshops and seminars (mgmt development)	9	1	2	3	4	76
Attend In-house courses	9	1	2	3	4	77
Complete formal self-study programs (correspondence, CAI)	9	1	2	3	4	78
Draw on personal skill and knowledge	9	1	2	3	4	79
Consult a periodical	9	1	2	3	4	80
Consult a handbook	9	1	2	3	4	81
Consult a reference text	9	1	2	3	4	82
Consult an internal expert	9	1	2	3	4	83
Consult an external expert	9	1	2	3	4	84
Informal contact with colleagues at your place of work	9	1	2	3	4	85
Informal contact with colleagues outside your work	9	1	2	3	4	86
Other, (Please specify and rank): ____________________	9	1	2	3	4	87

7. To what degree do the following influence your decision to participate in ***company-sponsored, formal continuing professional development*** activities:

	Not Important	Somewhat Important	Important	Very Important	
It directly assists you in your work	1	2	3	4	88
It is expected by your supervisor or department	1	2	3	4	89
It is required by your supervisor or department	1	2	3	4	90
It leads to career advancement/promotion	1	2	3	4	91
It provides an opportunity to get away from your work and learn what other colleagues are doing	1	2	3	4	92

(PLEASE TURN TO THE NEXT PAGE)

8. To what degree do the following influence your decision to ***participate in formal continuing professional development*** activities: Please use the following scale:

	Not Important	Somewhat Important	Important	Very Important	
Courses/program relevant to my needs	1	2	3	4	93
Convenient time	1	2	3	4	94
Convenient location	1	2	3	4	95
Personal time constraints	1	2	3	4	96
Professional/work constraints (lack of relief help, time off, etc.)	1	2	3	4	97
Program registration costs paid by employer	1	2	3	4	98
Sufficient information about course content	1	2	3	4	99
Sufficient information about available learning opportunities	1	2	3	4	100
Sufficient learning activities which match your learning style	1	2	3	4	101
Sufficient recognition for participating in learning activities	1	2	3	4	102
Sufficient confidence in your learning ability	1	2	3	4	103
Negative experiences with prior learning	1	2	3	4	104
Credibility of sponsor or presenters	1	2	3	4	105
Low personal priority in relation to other activities	1	2	3	4	106
Professional burnout	1	2	3	4	107
Personal desire to learn	1	2	3	4	108
Enjoyment provided by learning as a change of pace from the "routine"	1	2	3	4	109
Opportunity to meet/interact/exchange ideas with others	1	2	3	4	110
Affordable learning opportunities	1	2	3	4	111
Fear of professional obsolescence	1	2	3	4	112
Encouragement through an external source (e.g., employer, APEGGA)	1	2	3	4	113
Activity recommended by colleague	1	2	3	4	114
Professional/career advancement with potential for financial reward	1	2	3	4	115
Other (please specify and rank)	1	2	3	4	116

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9. What kind of ***formal recognition***, if any, would yc like to receive when attending formal continuing professional development activities? (Indicate **(X) only one please**).

- ☐ It is not important one way or another
- ☐ Certificate of completion
- ☐ Credit towards an APEGGA sponsored program 117
- ☐ Credit towards a technical society sponsored program
- ☐ Credit towards an advanced university degree
- ☐ Other, (Please specify)______________________

10. Please rate how effective you believe the following learning activities to be?

	Not Effective	Somewhat Effective	Effective	Very Effective	
Attending full-day courses (regular day program)	1	2	3	4	118
Attending evening courses	1	2	3	4	119
Attending intensive short courses	1	2	3	4	120
Completing correspondence courses	1	2	3	4	121
Attending seminars, conferences	1	2	3	4	122
Listening to tapes (audio or video)	1	2	3	4	123
Reading technical books, articles, papers, etc	1	[illegible]	[illegible]	4	124
Practice in an engineering, geological, or geophysical job	1	2	3	4	125
Discussion with knowledgeable people	1	2	3	4	126
Other (please specify)______________________	1	2	3	4	127

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11. Rate your agreement with the each of the following statements:

	Strongly Disagree	Disagree	Agree	Strongly Agree	
I view learning as relevant to my personal and professional growth	1	2	3	4	128
I have a strong positive attitude towards learning	1	2	3	4	129
I have an interest in reading (books, journals, magazines)	1	2	3	4	130
I am able to learn by myself..	1	2	3	4	131
I view myself as a learner	1	2	3	4	132
I become involved in learning opportunities for the sake of learning	1	2	3	4	133
I can list situations where I have been involved in self-initiated study	1	2	3	4	134
I prefer to learn in a group setting	1	2	3	4	135
I am able to assess my own learning needs	1	2	3	4	136
I am able to articulate my own learning needs	1	2	3	4	137
I use learning resources often (prof. journals, handbooks, etc.) ...	1	2	3	4	138
I become involved in learning activities when I have specific goals or objectives to meet	1	2	3	4	139
I am a curious, inquisitive person	1	2	3	4	140
I learn in a variety of ways (e.g,. reading, talking with colleagues, etc)	1	2	3	4	141
I am determined to do well in my endeavors	1	2	3	4	142
I am self-motivated rather than chiefly motivated by others	1	2	3	4	143
I make things happen before they happen to me.	1	2	3	4	144
I have developed skills in reasoning, critical thinking, and application	1	2	3	4	145
I have competent skills in communication (observing, listening comprehension and purposive reading)	1	2	3	4	146
I am able to cope well with career and occupational change	1	2	3	4	147
I am able to utilize different learning strategies	1	2	3	4	148
In both my personal and professional life, I have felt a readiness for change which motivated me to learn	1	2	3	4	149
I have the ability to organize my own learning experiences through identification of needs	1	2	3	4	150
I am open to new experiences, ideas, information, and insights ...	1	2	3	4	151

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Section II - Professional Practice Environment

12. On the grounds that it is in the "public interest", legislators in various American states have passed laws which require members of certain occupational groups to participate in a minimum level of continuing education in order to maintain their license to practice. ***Do your feel that the Government of Alberta should take similar steps and legislate mandatory continuing education activities for engineers, geologists,and geophysicists here in Alberta?*** **(Check only one please).**

☐ No ☐ Yes ☐ No opinion 152

If you answered "No" to Q12, is it because: (Indicate **(X)** in **more than one** box if you need to).

- ☐ APEGGA members already keep their knowledge and skills current in order to maintain their job or remain competitive. 153
- ☐ APEGGA members voluntarily remain competent as a matter of professional pride. 154
- ☐ APEGGA members maintain competence in order to avoid possible civil litigation. 155
- ☐ APEGGA members maintain competence in order to achieve the highest level of public safety 156
- ☐ APEGGA members are already required, or expected by their employers to engage in formal continuing professional development activities. 157
- ☐ The results of continuing learning professional development cannot be easily measured (quantified). 158
- ☐ It would encourage a lot of unprofessional "doing things just to get points". 159
- ☐ It would require tremendous effort and cost for little benefit 160
- ☐ Other, (please state):________________________ 161

If you answered "Yes" to Q12, is it because: (Indicate **(X)** in **more than one** box if you need to)

- ☐ Presently there exists no mechanism to insure that an engineer, geologist, or geophysicist maintains competence once he/she is admitted to APEGGA 162
- ☐ It would be an adequate way of meeting public expectations that APEGGA members maintain competence. 163
- ☐ APEGGA members need an objective or standard to strive for.

164

- ☐ The level of continuing learning professional development can be adequately measured (quantified). So why not? 165
- ☐ It would be another positive stimulus, another incentive. 166
- ☐ Other, (please state):________________________ 167

13. **Who should be responsible for maintaining competence of engineers, geologists, and geophysicists : (Indicate (X) only one please).**

- [ ] Employer only
- [ ] Employer more than engineer, geologist or geophysicist
- [ ] Equally shared responsibility of employer and engineer, geologist, or geophysicist
- [ ] More engineer, geologist, or geophysicist than employer 168
- [ ] Engineer, geologist, or geophysicist only
- [ ] No opinion
- [ ] Other, (Please State)________________________

14. **Please rate your agreement with each of the following statements:**

	Strongly Disagree	Disagree	Agree	Strongly Agree	
In my organization, taking part in formal continuing professional development is regarded as an important criterion for engineers, geologists, and geophysicists	1	2	3	4	169
After leaving university, engineers, geologists, and geophysicists must pursue their professional development by means of continuing professional development (formal and informal)	1	2	3	4	170
I consider myself to be up-to-date with the latest technological developments in my field of specialization	1	2	3	4	171
In general, the very fact that an engineer, geologist, or geophysicist is working in engineering, geology, or geophysics is sufficient to guarantee the development and maintenance of competence	1	2	3	4	172
Employers, universities, and other providers offer enough activities to meet the professional development needs of engineers, geologists, and geophysicists on a timely, relevant basis	1	2	3	4	173
A variety of challenging job assignments helps improve engineering, geological, or geophysical skill and knowledge..........	1	2	3	4	174
It would be useful for APEGGA to grant "continuing education units" for formal and informal continuing professional development that engineers, geologists, and geophysicists undertake........	1	2	3	4	175
The undergraduate engineering, geological, or geophysical education I received was well suited to contemporary job market needs..........	1	2	3	4	176

15. **Are you experiencing an increase in complex engineering and/or earth science "problems" in your work that have no easy solutions (e.g., environmental, quality, design, public safety, etc).**

☐ No ☐ Yes ☐ Not really sure 177

Comments:____

____

16. How many times in the past three months have you experienced a need for information, knowledge, or skills that ***could not readily be met***? (Indicate **(X) only one** please).

- ☐ 1-3 times
- ☐ 4-6 times
- ☐ 7-9 times
- ☐ 10-12 times
- ☐ 13-15 times 178
- ☐ More than 15 times
- ☐ Does not apply

Comments: ____

____

17. How effective was your ***university education*** in preparing you for the ***ongoing learning*** requirements of professional practice?
(Indicate **(X) only one** please).

- ☐ Not effective
- ☐ Somewhat effective 179
- ☐ Effective
- ☐ Very effective

Comments: ____

____

18. How effective was the ***APEGGA Member-in-Training*** process in preparing you for the ***ongoing learning*** you require for engineering practice? (Indicate **(X) only one** please).

- ☐ Not effective
- ☐ Somewhat effective 180
- ☐ Effective
- ☐ Very effective

Comments: ____

____

(PLEASE TURN TO THE NEXT PAGE)

19 How ***supportive*** **is your employer in encouraging you to seek out formal continuing professional development activities** (workshops, seminars, symposiums, etc.)? (Indicate **(X) only one** please).

- [ ] Not supportive
- [ ] Somewhat supportive 181
- [ ] Supportive
- [ ] Very supportive

Comments: ____

____

Section III - Demographics and current practice

20. Are you presently primarily employed in: (Indicate **(X) only one** please).

- [ ] A practicing engineer role (within a company)
- [ ] A consulting engineer role (consulting to external clients)
- [ ] A practicing geologist role
- [ ] A practicing geophysicist role 182
- [ ] A managerial role (supervisory, manager, executive)
- [ ] Retired from professional practice but maintain APEGGA membership
- [ ] Not presently employed
- [ ] Other (Please specify):____________________

21. Is your primary location of work in a major centre (more than 25,000 people) **(Indicate (X) only one** please).

- [ ] No - [ ] Yes 183

22. Does your work take you away from your primary city/town of work: (Indicate **(X) only one please)**.

- [ ] never
- [ ] occasionally 184
- [ ] regularly
- [ ] frequently

23. Your age as of November 1, 1995:

☐ 20-29 years
☐ 30-39 years
☐ 40-49 years
☐ 50-59 years
☐ 60-69 years

24. In what discipline is your formal university education:

☐ Geology
☐ Geophysics
☐ Aerospace engineering
☐ Civil engineering
☐ Chemical engineering
☐ Computer engineering
☐ Electrical engineering
☐ Industrial engineering
☐ Mechanical engineering
☐ Mining engineering 186
☐ Petroleum engineering
☐ Other (Please specify)________________

25. Check the highest level of university degree you presently hold: (Indicate **(X) only one please**).

☐ Bachelor's degree ☐ Master's degree ☐ Doctorate 187

26. Did you participate in a cooperative education (Coop) program during university?

☐ Yes ☐ No 188

(PLEASE TURN TO THE NEXT PAGE)

Section IV - Please share your opinions/viewpoints on the following to assist in understanding the emerging continuing professional development needs of APEGGA members:

27. What are the most pressing professional development needs of professional engineers and earth scientists today?

28. What improvements are needed in facilitating continuing professional development for professional engineers and earth scientists in Alberta?

29. What kinds of support are required to assist professional engineers and earth scientists in pursuing professional development activities?

THANK YOU FOR YOUR TIME AND COOPERATION

PLEASE RETURN THIS QUESTIONNAIRE IN THE ENVELOPE PROVIDED BY DEC 11, 1995

Sources referenced in the construction of the instrument:

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APPENDIX B

CORRESPONDENCE

Imagination Inspiration Innovation 1920 · 1995
APEGGA
The Association of Professional Engineers, Geologists and Geophysicists of Alberta

15th Floor, Scotia Place, Tower One
10060 Jasper Avenue
Edmonton, Alberta T5J 4A2
Tel: (403) 426-3990
Fax: (403) 426-1877

November 24, 1995

Dear APEGGA Professional member:

You have been randomly selected from the Association of Professional Engineers, Geologists and Geophysicists of Alberta register to receive this questionnaire which will assist us in improving our understanding of contemporary professional practice and how continuing professional development complements professional performance.

We encourage your participation in this study and urge you to complete and return this questionnaire no later than Monday, December 11, 1995. The information gathered will be used by the subcommittee of the Practice Review Board which is presently examining continuing competence in practice. The results will help clarify our understanding of the range of learning which occurs in professional practice. This will ultimately assist APEGGA to better support members at a time when the technological and regulatory environment of engineering, geology, and geophysics is changing profoundly.

Thank you for your continued support.

Robert Ross, P. Eng.
Executive Director and Registrar

MA/RR/ZH

Department of Educational Policy Studies
7-104 Education Centre North
University of Alberta
Edmonton, Alberta T6G-2G5

November 23, 1995

Dear APEGGA professional member,

I am completing a research project identifying the activities professional engineers and earth scientists in Alberta use to maintain performance in practice for my thesis in adult, career, and technology education at the University of Alberta. The results of this study will provide an Alberta perspective on learning in professional practice which will be beneficial for APEGGA, other Canadian professional engineering associations, and universities. This will provide a much needed Canadian perspective for determining how to effectively support continuing professional development for engineers and earth scientists.

This study examines activities believed to be associated with performance in practice. It also looks at conditions in the professional work environment which affect engineering and earth science performance. Would you please find time in your busy schedule to complete the attached questionnaire. It will take approximately 25 minutes. Participation in this study is entirely voluntary and you are under no obligation to respond, however your insight is crucial to understanding and improving engineering and earth science practice.

The questionnaire accompanying this package has been coded prior to mailing. The coding will only be used should telephone follow-up or a second mailing be required to increase the response rate. The key to the codes and the corresponding names are confidential and are accessible solely by myself. The key will be destroyed once the questionnaires have been returned for analysis. Your name was randomly chosen from the current APEGGA membership roster. All data collected in this study will be grouped in aggregate form, hence your responses will not be individually identifiable. Your anonymity and confidentiality are guaranteed.

Copies of the completed study will be available for review at the Faculty of Engineering, University of Alberta, the Faculty of Continuing Education, University of Calgary, the Association of Professional Engineers, Geologists, and Geophysicists of Alberta, and the H.T. Coutts library at the University of Alberta. A report on the study will also be submitted to APEGGA for possible publication.

Please return the questionnaire in the enclosed stamped, addressed envelope ***no later than Monday December 11, 1995***. Your participation in this study is greatly appreciated and important for improving the understanding of how engineers and earth scientists learn in practice.

Please feel free to contact me at (403) 468-3233 or (403) 945-4252 if you have questions or require assistance in completing the questionnaire. Thank you in advance for your assistance in furthering our understanding of activities which support performance in professional engineering and earth science practice.

Sincerely,

Michael Aherne
University of Alberta

Department of Educational Policy Studies
7-104 Education Centre North
University of Alberta
Edmonton, Alberta T6G-2G5

November 8, 1995

Dear

I am surveying Alberta Professional Engineers, Geologists, and Geophysicists to determine the range of activities they use to maintain competence and performance in practice. This survey will provide data for the completion of my master's thesis in Educational Policy Studies at the University of Alberta.

Your name was randomly selected as one of eleven Manitoba professional engineers considered for piloting the research instrument for this study. I thank you, as well as, Mr. David Ennis, Executive Director of APEM in advance for your consideration. Your feedback will go a long way in refining the instrument before it is released to 400 APEGGA members later this month.

I need to pre-test the questionnaire and would appreciate your assistance. I am asking that you complete the attached questionnaire at your earliest convenience. Please write on the questionnaire itself if you wish. Please return both this sheet and the instrument by fax at (403) 468-3233 or mail it back in the self addressed stamped envelope.

I would appreciate it if you could return the completed questionnaire by Friday Nov 17, 1995. Thank you in advance for your assistance. If you have any further questions, please feel free to contact me at (403) 468-3233 and I would be pleased to answer them for you.

Sincerely

Michael Aherne

Continuing Learning in Professional Engineering and Earth Science

Dear________________________

a) Approximately how long did it take you to complete the questionnaire?

___________________ minutes.

b) Were the directions clear and easy to understand?

Yes ( ) No ( )

c) Were the questions clear?

Yes ( ) No ( )

d) Did you have any problem in completing the questionnaire?

Yes ( ) No ( )

If yes, please explain. If you have any suggestions for modification, please include these:

____

____

____

e) Did the definitions which accompanied the questionnaire sufficiently assist in answering the questions?

Yes ( ) No ( )

If no, please explain.

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____

____

f) Any other suggestions are welcomed.