INCORPORATING INNOVATIONS INTO PRACTICE:

PROFESSIONAL LEARNING OF GENETIC COUNSELORS

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ABSTRACT

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Genetic counselors are healthcare professionals who work with patients and families affected by or at risk for conditions with a genetic cause or component. They act as purveyors of genetic and genomic testing and support the translation of test results into targeted and personalized medical care. Innovations, which arise and are introduced into practice continuously, compel genetic counselors to update their skills, knowledge, and approach quickly to ensure adequate and appropriate care of patients. The purpose of this study was to explore the professional learning strategies utilized by genetic counselors, with particular attention to learning which occurs in response to innovation. Utilizing critical incident questionnaires, interviews, and a database of credits accrued for continuing education, this study sought to contribute to a detailed understanding of genetic counselors' professional learning and how strategies may vary by specialty or years of experience. Genetic counselors were found to utilize reflection to identify learning needs arising within uncertain, complex, and ambiguous circumstances of practice, and match those needs to appropriate learning strategies. Prized learning strategies included reading to gather information, discussion with colleagues to curate alternative perspectives and past experiences, and experimentation to actively test ongoing apprehension.

Through strategies which were permeable, complementary, and active, genetic counselors demonstrated their abilities to synergize learning, practice, and novel, complex, ambiguous, and uncertain environments.

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Let me simply say that I remain deeply grateful for the love, time, energy, and patience you have invested, and I hope I have done right by your faith in me.

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Chapter I

INTRODUCTION

Genetic counselors are healthcare professionals who work with patients and families affected by or at risk for conditions with a genetic cause or component. They act as purveyors of genetic and genomic testing and support the translation of test results into targeted and personalized medical care. The current definition of genetic counseling describes a "process of helping people understand and adapt to the medical, psychological, and familial implications of the genetic contributions to disease" (The National Society of Genetic Counselors' [NSGC] Definition Task Force, 2006, p. 79). Genetic counseling occurs in the context of constantly evolving science and technologies underlying diagnosis and management of these conditions. Innovations, which arise and are introduced into practice continuously, compel genetic counselors to update their skills, knowledge, and approach quickly to ensure adequate and appropriate care of affected and at-risk individuals. Such serial innovations may include technological advances that enhance diagnostics, identification or clarification of genetic/genomic data that deepens understanding of disease mechanism, or novel therapies that expand the spectrum of management strategies (Profato, Gordon, Dixon, & Kwan, 2014, p. 679). Innovations have implications for genetic counselors' professional learning: "genetic counselors, like other healthcare professionals, are continually challenged to keep abreast of up-to-date, evidence-based information regarding their practice. In particular, we are tasked with trying to keep pace with technological advancements in genomics" (Wicklund & Trepanier, 2014, p. 452). This study aimed to better understand genetic counselors' professional learning in the context of innovation in genetic and genomic sciences and consequent adjustment of practice.

Genetic counseling is often referred to as a young profession as the first class of genetic counselors graduated in 1971 (National Society of Genetic Counselors [NSGC], 2014b; Resta, 2009, p. xv). There are now 37 genetic counseling graduate training programs in the United States and four in Canada, and over 4000 genetic counselors practicing in North America (Accreditation Council for Genetic Counseling [ACGC], 2017; NSGC, 2017a). The master's degree is considered the entry-level and terminal degree in the field, though a small number of genetic counselors hold additional advanced degrees in other disciplines (there is not a well-established niche for a doctoral degree in genetic counseling). Following graduation, genetic counselors sit for the American Board of Genetic Counselors' (ABGC) examination to obtain certification to practice; 22 states have enacted legislation requiring genetic counselors to have licenses (one additional state has passed legislation but is not yet issuing licenses) in addition to certification (ACGC, 2015; NSGC, 2017b). Maintenance of certification and licensure requires accrual of a prescribed number of continuing education units (CEUs) and professional activity credits (PACs), or reexamination within a specified timeframe; ABGC monitors and administers certification status for all diplomates (American Board of Genetic Counseling [ABGC], 2016).

Genetic counselors work in a variety of medical settings, including academic medical centers, private or public hospitals, and other organizations (NSGC, 2014b). Though training programs assume a generalist stance, genetic counselors often practice in one of several subspecialties: prenatal/reproductive genetic counseling, which historically has been the most prominent and populous subspecialty; cancer genetic counseling, which now represents the largest subspecialty; pediatric genetic counseling; and other clinical and non-clinical roles in clinical research, laboratories, and industry (NSGC, 2014b; NSGC, 2016).

In all subspecialty areas, genetic counseling practice is founded on science which is perpetually changing; shifts in approach subsequent to scientific innovations are relatively common.

> The profession of genetic counseling has undergone many transitions since its inception over 40 years ago; it has expanded from a primarily pediatric and obstetric focus at a time when genetic testing did not even exist, into multiple medical specialties that have access to rapidly changing genetic tests. (Ormond, 2013, p. 192)

Most recently, with the introduction of genomic technologies, the field is transitioning from a linear, single-gene, Mendelian model of rare, inherited conditions to a complex, genomic perspective of disease – both rare and common, inherited and acquired during an individual's lifetime (Profato et al., 2014, p. 679). Genomics can be concisely defined as "simultaneous testing of multiple genes (potentially spanning the entire genome)" (Profato et al., 2014, pp. 679-680). Innovations in genomics and derivative diagnostics – as the most recent scientific innovations – implicate modification of genetic counseling practice via the glut of information produced by efforts to sequence and interpret the human genome in toto, the application of big data analytics to genomics, and the growing awareness of gene-gene and gene-environment interactions (Weitzel, Blazer, MacDonald, Culver, & Offit, 2011). While the amount of information may be challenge enough, complexity of the information and uncertainty surrounding clinical implementation have been noted as barriers to genetic counselors' conducting truly informed consent for such testing (Boland et al., 2015). Though shift in the technological foundations is acknowledged to influence practice (Mills & Haga, 2014, p. 691; Ormond, 2013), debate exists as to whether these changes are of a qualitative (paradigmatic) or quantitative (scaled) nature.

Change in foundations of the field corresponds to the need for professional learning, yet little is known about how genetic counselors learn to incorporate scientific innovations into practice. Despite pressure to acquire and maintain cutting-edge expertise, education and training opportunities have remained comparatively constant: a master's degree from an accredited training program has served as the entry-level and terminal degree since the inception of the profession, and post-graduate continuing education opportunities consistently include professional conferences, workshops, literature review, and collaboration with peers. Dynamic circumstances in which a rapidly changing context of practice is juxtaposed with relatively static model for continuing professional education raises the question of how genetic counselors learn by selecting and pursuing learning strategies and resources that facilitate incorporation of scientific innovations into practice.

Context and Background

Previous research on professional learning and development of genetic counselors is limited. Several studies have explored specific aspects of professional learning such as the acquisition, upkeep, and enhancement of psychosocial skills (Eunpu, 1997; Hiller & Rosenfeld, 2000; Kennedy, 2000a, 2000b; Middleton et al., 2007), the experience and perceptions of genetic counselors with doctoral degrees (Atzinger et al., 2007), how genetic counselors perceive and reflect on their professional selves and their work (Abrams & Kessler, 2002; McCarthy Veach & LeRoy, 2012; Miranda, McCarthy Veach, Martyr, & LeRoy, 2016; Resta, 2002; Runyon et al., 2010; Wells, McCarthy Veach, Martyr, & LeRoy, 2016;

Zahm, McCarthy Veach, Martyr, & LeRoy, 2016), and how perceptions of professional development or expertise in genetic counseling compare with that of psychotherapists (Miranda, 2012; Miranda et al., 2016; Zahm, 2009; Zahm et al., 2016). These are pieces of the puzzle, but the big picture eludes. At the time of this writing, the researcher was unable to identify research that specifically explored the professional learning of genetic counselors in response to innovations in genetic and genomic sciences, which are currently increasing in scope and significance of implications for genetic counseling practice, so much so that the discussion on potential impact has breached professional circles and entered the popular media. Of note, for the purposes of this study, professional learning was defined as any activity in which a genetic counselor learned – acquired new knowledge, skills, or attitudes related to work. This was differentiated from professional development, which was understood as change in professional mindset or perspective from less to more complex systems of thought, accomplished through professional learning and over the course of many years.

The implications of innovations in genetic and genomic sciences beyond the profession of genetic counseling is evidenced by the growing number of pertinent articles and pieces in magazines, newspapers, and television. Articles explaining "new" genetic tests, uncertainty surrounding this type of information, and implications for individuals and families have appeared in the New York Times, The Atlantic Monthly, Business Insider, Time, and the NBC Nightly News, among countless other media outlets both lay and trade (Grady & Pollack, 2014; Hendren, 2013; Karow, 2013; Loria, 2015; Park, 2013). Many of these pieces highlighted that genetic tests are complex and often produce results of uncertain or ambiguous significance: "These tests are tricky territory, especially when it comes to genetic screening" (Hendren, 2013, para. 1). A series on NBC Nightly News entitled "The brave new world of genetic testing" included statements such as "sometimes the results are clear cut, but sometimes they aren't," as well as the following exchange: "Is there a lot of grey?" "Often there is, yes. And that is why we feel that genetic counselors are so essential to this process" (NBC Nightly News, 2015a; NBC Nightly News, 2015b). Perhaps the most recognizable of discourses on genetic testing is that surrounding the medical decisions of Angelina Jolie, the actress and public figure who discovered she carried a mutation in the BRCA1 gene which is known to significantly increase the risk of breast and ovarian cancer; Ms. Jolie subsequently opted to have prophylactic surgeries to reduce her risk of developing these diseases. Her disclosures in New York Times op-eds raised public awareness about genetic testing and inspired people to consider testing themselves, in a collective phenomenon called "The Angelina Effect" (Jolie, 2013; Jolie Pitt, 2015; Park, 2013). In an article exploring The Angelina Effect, the author stated the following:

> Scientific uncertainty is unavoidable. Genetic screening, if not in its infancy, is barely out of childhood. And the battle against all disease – especially cancer – is one we've been waging for millennia. The wisdom gained in the lab needs to be matched by the wisdom of both caregivers and patients, and that requires hard thinking and reasoned discussion. (Park, 2013, "The Map of Health," para. 5)

Altogether, the popular media reflects the concurrent curiosity and caution with which genetic and genomic innovations are received, by the general population and genetic counselors alike. It is in this context that genetic counselors are, along with everyone else, struggling with complexity, ambiguity, and uncertainty and attempting to make sense and best use of innovations in genetic and genomic sciences.

Genetic counselors have been identified as uniquely positioned to transition genomic technologies into clinical practice (Mills & Haga, 2014; O'Daniel, 2010). However, there is debate as to the kind and extent of effort needed to do so. Some suggest that incorporation of genomics into genetic counseling practice necessitates a paradigmatic shift (Mills & Haga, 2014; Weitzel et al., 2011), so extensive as to necessitate a change in name.

> Genetic counselors will play an important role in ushering in this new era of testing; however, it will warrant a shift from traditional genetic counseling to 'genomic counseling.' This shift will be marked by a move from reactive genetic testing for diagnosis of primarily single-gene diseases to proactive genome-based testing for multiple complex diseases for the purpose of disease prevention. (Mills & Haga, 2014, p. 689)

The above vignette represented accommodation of complexity, allowing the extensive influence of new technology to morph practice structures. Alternatively, others suggest that genomics can be incorporated into genetic counseling as a natural extension of the profession's core skills (Everett, Gustafson, & Raymond, 2014; Gettig, 2010; Wicklund & Trepanier, 2014), a shift in scale rather than paradigm, an assimilation of new information into existing patterns of work. Even still, it is acknowledged that "the routine incorporation of genomic medicine will likely induce differences in the *scope, approach* and *process* of genetic counseling" (Ormond, 2013, p. 189) and will potentially require that genetic counselors critically assess and update knowledge and models of professional practice (Wicklund & Trepanier, 2014).

Given the evidence that genetic counseling practice is currently influenced by innovations in genomic technologies, some have called for a reappraisal of the content of graduate and continuing professional education offerings to assist genetic counselors with absorbing this expanded scope and assuming this new role (O'Daniel, 2010; Weitzel et al., 2011; Wicklund & Trepanier, 2014). However, little is known about the professional learning of genetic counselors once finished with the requirements of graduate training. Indeed, little is known about the continued professional learning and development of genetic counselors in general. From the moment a genetic counselor enters the profession, she is responsible for "demonstrat[ing] initiative for continued professional growth... display[ing] a knowledge of current standards of practice and show[ing] independent knowledge-seeking behavior and lifelong learning," as dictated by established practice-based competencies (ABGC, 2013a). Yet the content and process of this continued professional learning remains largely unexplored, as does the extent to which capacity to learn could be complicated by the complexity, ambiguity, and uncertainty of innovations.

Problem Statement

In line with the tenets of the profession and recognizing contextual factors surrounding genomics, innovations confer on the genetic counselor a pressing responsibility to update professional skills and knowledge to incorporate innovations into practice. Few studies were published about the learning, strategies, and resources utilized by genetic counselors to acquire new knowledge, skills and attitudes that, when enacted, alter a professional's approach to her work. Indeed, previous research about continued professional learning activities of genetic counselors was limited. The purpose of this study was to explore the learning strategies and resources utilized by genetic counselors, with particular attention to the learning which occurs in response to innovation. Knowledge of the professional learning of genetic counselors could guide selection and enhancement of existing training and education endeavors, support improvements in daily practice, and facilitate the translation of advances in basic sciences to clinical care. Additionally, such knowledge could inform the development of new professional learning opportunities such continuing learning and education programs or coaching resources.

Purpose of the Study

To better understand genetic counselors' professional learning in response to innovation, this study aimed to answer the following research question: how do genetic counselors leverage learning to incorporate scientific innovations into practice? This study was guided further by additional research sub-questions:

- What strategies do genetic counselors utilize for continued professional learning?
- What roles do colleagues play in the professional learning of genetic counselors?
- How do specialization and years of experience influence selection of strategies?
- How does ambiguity tolerance influence selection of strategies?

The goal of this study was to gather genetic counselors' perspectives on the above research questions. By utilizing critical incident questionnaires, interviews, and a database of continuing education activities, this study sought to contribute a detailed understanding of genetic counselors' professional learning, with exploration of how learning may be influenced by point in career or specialty area. Rapid cycles of innovation influencing practice create conditions for which this study offered insights regarding learning strategies corresponding to a genetic counselor's professional situation.

The Researcher

The researcher worked as a clinical cancer genetic counselor at a major medical center in New York City for seven years. It was during this time that genetic testing for inherited cancer predisposition transitioned from condition-specific testing to expanded panel testing (for example, in the case of hereditary breast cancer, from a test of the *BRCA1* and *BRCA2* genes to panel testing of up to 25 genes associated with an increased risk to develop the disease). The researcher's experiences of assessing and adjusting her practice subsequent to the introduction of expanded panel testing in many ways engendered curiosity regarding the topic of professional learning in response to innovations. She experienced confusion, excitement, self-doubt, and satisfaction while navigating the ambiguities of new technologies, altering her counseling framework, monitoring and responding to patients' reactions to new components of patient education, counseling, and informed consent. Personal responses were defined and modified by the circumstances in which they occurred: a culture of interprofessional interactions, giving rise to consensus and contradiction among colleagues of similar and different disciplines, yielding insights into alternative opinions, responses, and adjustments in response to new technologies; a patient population of extensively varied ethnicities, socioeconomic statuses, ages, and reasons for referral; a relatively permissive healthcare system which prioritized patient decision-making over prescriptive guidelines regarding eligibility for testing; and a vibrant, fast-paced metropolitan setting with an established, extensive community of genetics professionals.

In additional to clinical work, the researcher worked with a clinical research study as the genetic counselor for a tumor sequencing research study. This opportunity extended the range of healthcare professionals from whom she learned through discussion and modeling. Distinctions between research and clinical spheres of practice - the processes, priorities, values, and challenges in each – were explored, as were the complexity, ambiguity, and uncertainty of acting at the cutting edge of applications of new technologies, without the comfort and clarity of established guidelines and standards.

In the above clinical roles, the researcher perceived the prominence of positivism through the culture of medicine and the framework of the scientific method. Subsequent work as an educator provided a constructivist counterpoint to her previous training and practice, and introduced perspective on meaning-making – qualitative, complex, and negotiated in tone. The researcher assumed increasing educational responsibilities by teaching and supervising genetic counseling graduate students, which eventually led to a full-time position as an associate program director of a genetic counseling graduate training program. Moving from a clinical to an academic role inspired sharper attention to learning throughout a career, from baseline training through advanced and continuing education.

The researcher's own professional learning and development has been constituted by a collection of experiences: reflective practice; supervision with a licensed social worker; ongoing discussion and dialogue with colleagues in genetic counseling, bioinformatics, and adult education; iterative experimentation with alternative approaches to working with patients; formal education in adult learning via in-person coursework; attendance at professional conferences, workshops, departmental case conferences and journal clubs; online courses in ethical research, statistics, and topics in genetic counseling; participation in working groups of professional organizations; teaching graduate courses and facilitating continuing education opportunities for genetic counselors; and conducting research. Her research interests have persistently focused on professional development and continuing education of genetic counselors, beginning with her master's thesis and into the present study.

Having been immersed in professional development and continuing education concepts and practices throughout her career, the researcher acknowledges the potential for bias in studying a topic and a profession in which she has personal experience. Multiple tactics were employed to mitigate researcher bias, including deep personal reflection to inform bracketing of assumptions, keeping a study journal and data auditing log, and discussion of analyses with adult education and genetic counseling colleagues. These efforts aimed to limit potential distorting effects of idiosyncratic opinions and perspectives.

Assumptions

This study assumed that scientific innovations perpetually arise and directly – though perhaps subtly and to differing degrees – affect the ways in which genetic counselors learn and approach their work. No preconceptions were made as to the type and kind of innovation expected to affect practice; that is, innovation could be defined or identified as advances in testing technology, scientific breakthroughs in understanding of disease mechanisms, novel medical management, shifts in policy, or any other phenomenon of participants' choosing. The upshot of a particular innovation was assumed to be dependent upon the nature of the innovation itself in conjunction with the individual practitioner's incorporation of the innovation as mediated by her specialty area, years of experience, ambiguity tolerance, interactions with other professionals, and context in which she worked.

It was assumed that genetic counselors are periodically compelled to examine their practice, become acquainted with innovations, assess potential implications of innovations in terms of current practice patterns, and adjust course accordingly to incorporate innovations into practice; importantly, learning processes were assumed to fundamentally underlie and constitute each of these components. Finally, this study was predicated on the assumption that genetic counselors are able to take perspective on their practice and professional learning to report their experiences of learning, particularly in response to innovations as they arise and impact practice.

Rationale and Significance

As the profession of genetic counseling is integrally tied to scientific innovations that propagate the knowledge and tools of the trade, exploration and understanding of how genetic counselors learn to incorporate innovations into practice is of critical importance. Knowledge of opinions and perspectives on professional learning in response to innovation is readily applicable to current and future genetic counseling practice, assuming the rapid rate of such innovations requires continuous assimilation and accommodation by professionals. As the genomics "revolution" maintains momentum, genetic counselors would be well served by drawing on learning strategies and resources that assist them to update and adapt professional knowledge, skills, and attitudes and enable them to navigate contexts of increasing complexity, ambiguity, and uncertainty. A better understanding of efficacious strategies and resources allows for more discerning and sophisticated selection of learning interventions for specific situations given genetic counselors' subspecialty, years of experience, ambiguity tolerance, and collegial network. Tailored professional learning, in turn, would be expected to promote the translation of genomic science into genomic medicine, and ultimately sustain informed and efficacious care of patients through changing contexts.

Though this study centered on the professional learning of genetic counselors who routinely encounter scientific innovations and translate cutting-edge evidence into clinical care, apt analogy can be made to the learning of other professionals grappling with rapid cycles of innovation. This study informs enhanced professional learning opportunities for healthcare professionals who interface with genetic and genomic technologies and information and could be similarly useful in medical specialties which depend on other complex sciences given comparable high stakes of application to patient care. As genetic and genomic testing is progressively incorporated into mainstream medicine, healthcare professionals of any ilk would benefit from a detailed understanding of learning which furthers inclusion of these innovations into practice. Indeed, physicians, nurses, and many other healthcare providers may encounter and utilize genetic and genomic information during clinical assessment and management.

Outside of medicine, scientists in technologically-oriented fields might also be expected or required to find their way through significant shifts in the context and content of practice prompted by innovations, and therefore could draw upon the findings of this study to frame the search for learning strategies and resources appropriate to their particular professions. Scientists working in environments characterized by rapidity, complexity, ambiguity, and uncertainty might note parallels with genetic counseling and therefore find timely and practical ideas for their own professional learning among these pages.

Knowledge of professional learning informs both entry-level training and continuing professional learning and education opportunities designed to support genetic counselors, healthcare providers, and scientists as they navigate increasingly complex professional landscapes rife with emerging innovations. While these professionals might seek to consume learning opportunities, this study also informs the work of adult educators and program planners who develop and implement learning experiences across career trajectories of these professionals. Adult educators supporting those who work in contexts of rapid change, serial innovations, complexity, ambiguity, or uncertainty might better anticipate the learning needs of their clients as well as factors modifying learning by reference to this study. Such awareness presents adult educators with the opportunity to customize professional learning opportunities to professionals working in unique, challenging environments.

Chapter II

LITERATURE REVIEW

To establish a foundation of concepts and theories for this study, a literature review was conducted to explore previous research on professional learning and development of genetic counselors, with focus on the implications of genomic technologies. Additionally, adult education literature on learning from experience, reflective practice, community of practice, and continuing professional learning was utilized to further shape the approach of this study, develop research questions, and guide analysis and interpretation of findings.

Along these lines, the PubMed database was used to repeatedly search the genetic counseling literature using various combinations of the following terms: “genetic counseling,” “professional development,” “adult education,” “adult learning,” “continuing professional learning,” “continuing professional education,” “continuing education,” “training,” “genomics,” “complexity,” and “ambiguity.” All articles returned for each search were reviewed by title and abstract and those articles assessed as relevant to the study were retrieved and comprehensively reviewed. The reference sections of all relevant articles were mined for other related articles, which were searched, reviewed by abstract, and retrieved and comprehensively reviewed as deemed contributory to the topic. Google Scholar was also used to identify articles with citations to key articles related to the research questions. In a similar fashion, Google Scholar and Teachers College library holdings were searched using the terms listed above, as well as “community of practice,” “learning community,” “healthcare,” “reflective practice,” and “social learning.”

From this process of culling the literature, several themes emerged and shaped the development of this study's research questions and design. The body of literature addressing the professional development of genetic counselors reviewed below first frames how learning is conceptualized in the genetic counseling literature, examines practical applications of conceptualizations of learning, and finally focuses on learning in the current context of professional practice fraught with complexity and ambiguity. A review of adult education theories follows, particularly learning from experience, communities of practice, and continuing professional education (CPE).

As the study progressed, the genetic counseling literature was periodically searched anew with the original key words to gather and incorporate additional and emerging research relevant to this study. Relevant studies were included as appropriate into sections on genetic counselors' professional development and responses to innovation. Similarly, additional investigation of the adult education literature was conducted to explore the potential contributions of new research on experiential learning, communities of practice, and continuing professional education.

Professional Development of Genetic Counselors

Literature on professional development in genetic counseling showed nascent attempts of applying professional development theories generally and from related fields to this profession. The following section reviews various conceptions of professional development – as a means of growing expertise or expressing a professional value – as they appeared in the genetic counseling literature. Manifestations of these conceptions are also described, most significantly as experiences and opinions on formal education in the form of advanced degrees as well as informal methods of reflection. Finally, literature on the contemporary context of practice in genetic counseling is reviewed, with careful attention to connection between new technologies and professional learning.

Conceptualizations of Learning in Genetic Counseling

Several studies provided insight into perspectives on professional development in genetic counseling yet only began to inform on complex, multilayered phenomena of professional learning and continuing education. References to professional learning and development, when not quite general, often spoke to the acquisition of discrete knowledge or skills. Acceptable methods for increasing medical and scientific knowledge included several formal learning opportunities such as “attendance at national or regional meetings of the NSGC or other national genetics meetings, as well as involvement in local genetics conferences” (Scott, Walker, Eunpu, & Djurdjinovic, 1988, p. 197), and “participation in local university or medical center conferences, lectures, and rounds and involvement in teaching of other medical professionals as a means of assuring the counselors’ own self-education” (Scott et al., 1988, p. 193). Continued professional learning and development as operationalized by the field’s professional societies, in the form of maintaining certification (frequently a requirement to practice as a genetic counselor) through the American Board of Genetic Counseling (ABGC), require accrual of a specified number of continuing education units (CEUs). CEUs are most readily and abundantly available by attending the National Society of Genetic Counselors’ (NSGC) annual conference, which historically consisted of mostly lecture-style sessions aimed at increasing participants’ knowledge, though recently have incorporated an increasing proportion of interactive sessions. In terms of enhancing counseling skills, genetic counselors were noted to participate in peer supervision (Dunlop, Barlow-Stewart, Butow, & Henrich, 2011; Lewis et al., 2017) and reflection (Zahm, 2010), similar to models found in psychotherapy and social work.

The aforementioned professional expectation of lifelong learning was echoed in a study on personal values of genetic counselors. Pirzadeh et al. (2007) explored the personal values of 292 genetic counselors (a 22.2% response rate to an email invitation sent to the National Society of Genetic Counselors listserv) by utilizing the Schwartz Universal Values Questionnaire (SUVQ). This tool asked participants to rank 56 values, each accompanied by a definition, by cross-comparison with one another. Demographics were collected via a twelve-item survey. Additionally, participants were asked how important values are in ethically challenging situations. Findings revealed that "*benevolence* and *self-direction* were greater than one standard deviation above the mean for all 56 items (M = 4.42; SD = 0.59). *Power* was close to 3 standard deviations below the overall mean… The standard deviations for benevolence, self-direction, and power indicate that respondents were particularly consistent in these ratings" (Pirzadeh et al., 2007, p. 769). The authors stated that these findings are remarkably similar to a previous study of mental health professionals and consistent with goals of the field (Pirzadeh et al., 2007, pp. 769-770), which is unsurprising as genetic counseling includes supportive counseling and is framed as a helping profession. Interestingly, the third most important value espoused by genetic counselors was that of *achievement*, defined as "personal success through demonstrating competence according to social standards… a value motivated by self-enhancement" (Pirzadeh et al., 2007, pp. 768-769). Support of this value suggested that many genetic counselors are amenable to the profession's language of continued growth of their knowledge and skill in accordance with acquiring and maintaining expertise; however, the mechanisms underlying this learning and development were not addressed. The authors suggested that values may be subject to change over time and research should be conducted on whether "the effects of age and *historical events*, for example, whether rapidly expanding genetic knowledge, tests, and technologies affect how they adhere to and express their values in clinical practice" (Pirzadeh et al., 2007, p. 771). Indeed, it would be interesting to understand the influence of such factors on the self-direction and achievement-mindedness of genetic counselors as they navigate professional learning in response to innovations such as genomics. Such values could be expected to shape the professional learning of genetic counselors.

Runyon, Zahm, McCarthy Veach, MacFarlane, and LeRoy (2010) studied professional development outcomes of genetic counselors. They offered an anonymous online survey to practicing genetic counselors via the NSGC listserv. Eight demographic and two open-ended questions ("What do genetic counselors learn about themselves while *on the job*?" and "What advice would they give to genetic counseling students just starting their careers?") were included; 173 participants completed all demographic questions and both open-ended questions (a 22.3% response rate). Descriptive statistics were calculated from demographic data and content analysis was performed on responses to the two open-ended questions (themes were developed generatively without a pre-determined theoretical framework and the frequency of each theme was counted across the entire open-ended data set).

The authors' commentary, rather than the results of their study, was of particular interest with respect to this review. Runyon et al. (2010) highlighted the lack of empirical research on professional development of genetic counselors (p. 371). Further, they speculated on the utility of exploring the particulars of professional development for practicing genetic counselors, arguing that "greater understanding of professional development may help genetic counselors better comprehend, anticipate, and successfully deal with their own developmental processes and outcomes as well as those of their students, supervisees, and colleagues" (Runyon et al., 2010, p. 373). Finally, they enumerated various topics for future research, including "possible differences in professional development due to experience, specialty area, amount/type of post-degree supervision, and other characteristics" (Runyon et al., 2010, p. 384) and "whether the nature and depth of one's learning changes with increased experience in the field… [and] the nature and timing of professional development catalysts and counselor characteristics (e.g., self-reflection)" (Runyon et al., 2010, p. 385). In these ways, the authors provided the most contemporary analysis of the state of understanding of professional development of genetic counselors, whilst conflating development with learning. However, professional development was framed as a process contained within and dependent upon the individual and was examined primarily through its outcomes; external factors such as changes in the context or content of practice via technological advances were not considered or incorporated, nor were specific methods for pursuing professional development explicated.

Several other studies have attempted to define professional development of genetic counselors, though the concept continued to escape thorough operationalization. Two articles took as their shared foundation a series of narratives in which genetic counselors described their changing notions of themselves as professionals. In 2002, Abrams and Kessler embraced an almost literary treatment of several vignettes, written from the perspectives of seven counselors at various stages of their careers. The authors suggested that "the sequence of vignettes approximates a developmental path many genetic counselors may follow in their careers" (Abrams & Kessler, 2002, p. 6). Resta (2002), in response to Abrams and Kessler (2002), argued that "by analyzing [the vignettes], by getting the perspectives and interpretations of peers and mentors, the experiences of these anonymous 'Everyman' counselors can serve as vehicles for the professional growth of other genetic counselors" (p. 19). Resta (2002) suggested the first few years of professional development focus on knowledge acquisition; efforts of this initial phase gradually confer a burgeoning sense of confidence; from this sense of confidence in knowledge, many genetic counselors turn their attention to honing psychosocial counseling skills; and finally, with both medical knowledge and psychosocial counseling skills established to the counselor's satisfaction, she may then turn her attention to assisting in the professional development of others (Resta, 2002, pp. 21-22). This hypothetical path suggested that a genetic counselor was likely to reach a threshold of expertise in which she was internally secure enough to turn attention outwards and guide others. This description implied a linearity belying perturbation from radically new technologies that periodically shift questions and expectations for what may be considered adequate expertise or competence.

Continuing in this vein, it was useful to review existing literature on expertise in genetic counseling to clarify the assumption that expertise serves as a reasonable outcome of professional development and continued professional learning. Miranda (2012) explored concepts of expertise in genetic counseling by focusing on "the *person* of the genetic counselor" (Miranda, 2012, p. 5). She sought to identify characteristics that contribute to the development of expertise in individual genetic counselors and argued that quantity of experience is rarely precisely proportional to quality of practice (Miranda, 2012, p. 3). Miranda (2012) commented on how little was known about the professional development and expertise of genetic counselors and mentioned that existing knowledge was not readily applicable to practice (Miranda, 2012, pp. 12-13) – which was concerning given the significant changes anticipated as a result of the spread of genomic technologies might be expected to further the gap.

To anchor her study of expertise, Miranda (2012) used the theoretic models of professional development and definitions of expertise in other professions – particularly social work, psychology, nursing, and physical therapy – to frame the concept as it appears in genetic counseling (Miranda, 2012, pp. 23-72). She argued that expertise in these fields shared the following four components:

> 1) a multidimensional knowledge base developed through life and work experience, 2) an ability to recognize patterns within their clinical encounters 3) a set of more elaborate cognitive skills than those professionals who are less developed, 4) and a strong motivation to continue learning. (Miranda, 2012, p. 66)

Participants were recruited via a two-step process. First, an invitation was sent to 54 leaders of the field, defined as past presidents of the National Society of Genetic Counselors (NSGC) or NSGC award winners, asking them to identify genetic counselors whom they considered top notch and to whom they would refer friends, families, and/or oneself. Six of these responded, yielding a total of 27 nominations. Nominees were required to be certified by the American Board of Genetic Counseling (ABGC) and be practicing or have practiced in last two years. The 27 nominated participants were emailed invitations to participate in the study, to which 15 people replied (Miranda, 2012, pp. 80-83). Interview questions were emailed in advance of the telephone interview and consisted of 16 demographic questions and 16 questions on "distinguishing characteristics of master genetic counselors; necessary attitudes, values and traits; how master counselors develop; the impact of genetic counseling on the counselor; positive and negative experiences; what constitutes success; and inspirations and motivations" (Miranda, 2012, p. 84). Interviews were digitally recorded. The researcher personally transcribed all recordings, then applied a version of consensual qualitative research to analyze the data, which resulted in 75 total categories in 14 domains (Miranda, 2012, p. 98), broadly describing personal characteristics of expert practitioners, patient interactions, the nature of success in practice, and impressions of the profession as a whole (Miranda, 2012, p. 5).

The following categories were identified: "An Insatiable Curiosity, Love of Learning, Life-long Learning (*n*=14) … Learning is an inspiration and motivation, and it is fueled by an innate curiosity" (Miranda, 2012, p. 108) and "Constantly 'Seeking and Searching' (*n* = 9) ... These master genetic counselors seem to thrive on continual development and growth, what one described as 'a dynamic seeking and searching'" (Miranda, 2012, p. 110). Also of note, "*all* of the master genetic counselors described a process of development" (Miranda, 2012, p. 122). Other findings of the Miranda study (2012) included the interplay of rapid technological advances and the inspiration to learn (Miranda, 2012, pp. 165-166), as well as the utilization of formalized educational activities such as professional meetings, reading the medical literature, or conducting research" (Miranda, 2012, p. 167). These themes could potentially relate to continued professional learning beliefs and practices which genetic counselors apply to their understanding of genomics and other scientific innovations, though the generation of an in-depth description of such beliefs and activities was not included in this study.

Miranda et al. (2016) subsequently published an article on this work in which master genetic counselors were noted for their deep and abiding commitment to learning: "They view their professional development as ongoing, influenced by colleagues, patients, mentoring, multicultural considerations, and their own family of origin. They also believe professional development of expertise occurs through critical reflection upon the experiences one accrues" (Miranda et al., 2016, p. 767). These were illustrated to give rise to mindsets which could ascertain, navigate, and embrace complexity (Miranda et al., 2016) in their work with patients.

To turn to a broad investigation of professional development of genetic counselors, Zahm (2009) took it as the focus of her dissertation, "From Graduate to Seasoned Practitioner: A Qualitative Investigation of Genetic Counselor Professional Development". In her impressive review of the literature, Zahm concluded that "literature on [genetic counselors'] overall professional development processes is scant. Indeed, it is too scant at this point to articulate a formal model of professional development" (Zahm, 2009, p. 5). She categorized extant articles into two categories: those that presented subjective experiences in a manner similar to a narrative (of which the aforementioned Abrams and Kessler article is an example) and studies that selected specific aspects of professional development rather than exploring the topic as a whole (p. 6). Zahm (2009) brought her own perspective to the topic by first providing an operationalized definition of professional development as "an ongoing process with a desired result of competence, confidence, and 'professionalism' through both internal (intrapersonal) and external (interpersonal) means" (Zahm, 2009, p. 8).

Thirty-four participants were obtained from a pool of 96 individuals who indicated interest in being interviewed by providing their email addresses during an initial survey to collect demographics and confirm eligibility (overall response rate not provided). Participants subsequently completed semi-structured telephone interviews to discuss their professional development experiences. Participation was limited to genetic counselors whose main work responsibility was patient care; participants were evenly distributed among three experience levels – novice (0-5 years of practice), experienced (6-15 years), and seasoned professional (greater than 15 years). The main research questions included:

> (1) What constitutes professional development for genetic counselors? (2) How do these professional development processes occur for genetic counselors? (3) What facilitates and/or impedes professional development? (4) How does genetic counselor professional development vary as a function of experience level? And (5) How does genetic counselor professional development compare/contrast to psychotherapist development descried by Skovholt and Ronnestad (1992a)/Ronnestad and Skovholt (2003) and Orlinsky et al. (2005)? (Zahm, 2009)

Participant responses to the above interview questions were audiotaped and transcribed. Zahm (2009) employed the consensual qualitative research method during analysis, which she described as a combination of phenomenology, grounded theory and comprehensive process analysis to analyze participants' responses (p. 65). This method, characterized as inductive, "allows for an organic emergence of themes from the interview data instead of an imposition of a pre-existing analytical framework" (p. 65). However, it was noted that the author stated the questions themselves were adapted from pre-existing concepts in the psychology and genetic counseling literatures (p. 60), which could be viewed as constituting pre-existing frameworks. This also raised concerns regarding the validity of assuming significant similarity between two different professions.

Results suggested that participants conceived of professional development as primarily a means of improving specific skills, but also as a mechanism for broadening the range of one's professional activities and advancing one's career (Zahm, 2009, p. 192). It was acknowledged that the study was conducted prior to significant spread of clinical availability of genomic technologies. The author concluded that, for genetic counselors, professional development was structured as

> a continuous process with all aspects of professional development being affected – and affecting others – at any given time, from graduation to retirement. Professional development does not stop, even at times where one does not necessarily notice profound movement or growth. (Zahm, 2009, pp. 178-179)

This illustrated that a genetic counselor may increase knowledge and skills which coalesced into an underlying and persistent developmental process, though mechanisms of learning giving rise to such development were not delineated in this study.

Subsequent publication on this research (Zahm et al., 2016) delineated unique findings perhaps most germane to genetic counselors working in the genomics era. Motivations to continue practicing included "novelty of information and growth of the field; fascination with genetics and intellectual stimulation from the challenges to learn and convey complex information" (p. 826). This enthusiasm was not without a counterpoint of hesitation, as "genetic counselors from all experience levels variously mentioned optimism and pessimistic uncertainty about the future evolution of genetic counselors' roles and jobs. Their perspectives included fear about the future, particularly as genetic information continues to proliferate rapidly" (Zahm et al., 2016, p. 828). Keen awareness of challenges was mirrored by nuanced personal views of professional development in the forms of distinction between deliberate and unexpected contributions and an increasing number of activities targeted to professional growth (Zahm et al., 2016, p. 827).

Both the Miranda (2012) study and the Zahm (2009) study were erudite in illustrating detailed insights into professional development of genetic counselors, and in acknowledging the process was ongoing and involved others (Miranda, 2012; Zahm, 2009). Neither distinguished between professional development and professional learning, and both were limited by two core assumptions: a focus on genetic counselors in clinical practice as opposed to those practicing in expanded roles such as industry and research, and analogy to psychotherapy or other health professions. As clinical research and industry were – and continue to be – rapidly expanding areas of practice (NSGC, 2014b), the conception of expertise delineated in the Miranda (2012) study could be construed as narrow, excluding the experiences of a significant portion of the profession, thus restricting the ability to apply results toward insights into the profession as a whole or to new contexts such as the developing scenario of working with genomic technologies.

With respect to analogy to other professions, Miranda (2012) stated that “results of this study indicate that master genetic counselors share many of the characteristics and qualities found in research on experts in related helping and medical fields such as psychotherapy, social work, physical therapy and nursing” (Miranda, 2012, p. 239). The use of foundational theoretical constructs and methodologies used in other professions called the similarity of results into question. Though genetic counseling is partially a supportive service during which counseling techniques may be employed, it is also an educational intervention such that genetic counseling practice may significantly diverge from psychotherapy by virtue of shifting the provider-patient interaction to be more bidirectional and potentially more directive in nature (NSGC Definition Task Force, 2006). Furthermore, process studies on genetic counseling demonstrated that genetic counseling shows greater similarity to educational or teaching models than to counseling models. Roter, Ellington, Hamby Erby, Larson, and Dudley (2006) videotaped standardized patient exercises with 177 genetic counselors to determine the prevalence of “teaching” and “counseling” practices. They described teaching practice as “emphasizing the transmission of information in a meaningful manner” and affirmed both teaching and counseling as “integral to professional practice” (Roter, Ellington, Hamby Erby, Larson, & Dudley, 2006, p. 210). The authors emphasized that all models of practice are “heavily laden with information, as might have been expected given the enormity of the teaching aspect of the genetic counseling task” (Roter et al., 2006, p. 218). A similar conclusion as to the prominence of educational over counseling aspects of genetic counseling was drawn by Meiser, Irle, Lobb, and Barlow-Stewart (2008) when they reviewed 18 studies on the process and content of genetic counseling practice and stated that many “components of genetic counseling make its information-giving and educational part central, leading to the possibility that communication aspects of care may be more salient in determining client outcomes (Shiloh et al. 1990), compared to other types of medical consultations” (Meiser et al., 2008, p. 435). Though not misrepresentative of the work of genetic counselors, underlying assumptions of analogy as employed by both Zahm (2009) and Miranda (2012) were expected to significantly influence methodologies, data analyses, and ultimately study findings. Additionally, by opening participation to all genetic counselors regardless of work setting and analyzing data without reference to other healthcare professions, the current study extended from the Zahm (2009) and Miranda (2012) studies could be extended.

Whereas Zahm (2009) and Miranda (2012) examined the professional development and expertise of individual genetic counselors, Rom (2006) analyzed the process of professionalization of genetic counseling as a field. The author sought to understand perceptions of the development of the genetic counseling profession, the role of genetic counselors in service delivery, and why the profession was not fully autonomous by studying the field from a sociological perspective and employing theories of “professionalization and the institutionalization of professions” (Rom, 2006, p. 4). Twenty-one key informants were purposely selected by virtue of seniority or holding leadership positions in professional organizations, as these individuals were considered most likely to be informed on the overall historical development of the field (Rom, 2006). Key informants were asked to provide referrals to others considered influential in the professionalization process, which yielded 17 additional participants (Rom, 2006). All 38 participants were invited by email or letter to contact the researcher to schedule an interview and subsequently completed an in-depth, semi-structured interview with the researcher. Interviews were voice-recorded and transcribed by an external service (Rom, 2006). A grounded theory approach was used to analyze results, and Atlas.ti was used for data indexing and analysis (Rom, 2006).

Several findings of the Rom study shed light on professional learning. Results suggested that those learning endeavors primarily aimed at career advancement may be fundamentally opposed by the lack of advancement opportunities available to genetic counselors; Rom (2006) explained “traditional genetic counseling positions have little opportunity for advancement both in terms of professional responsibility and salary” (p. 105). Due to this “hard wood ceiling,” the author suggested that “many people, while not leaving the genetic counseling profession entirely, ‘move into another area, such as being a program director… or going to a newborn screening program… moving into clinical research’ (GC2SC)” (Rom, 2006, p. 105). These statements highlighted that genetic counselors may direct their development laterally into specializations as they encounter obstacles to upward movement; this theory was taken up by a group exploring advanced training options for practicing genetic counselors a decade later as they posit the benefit of crafting a career lattice for genetic counseling (Baty et al., 2016). An alternative explanation for specialization was offered by Rom (2006), as a response to increasing informational demands of practice.

> The majority of respondents interviewed mentioned the increase in specialization as the genetic counseling field has grown… Much of this increase in specialization is associated with the increase in knowledge of genetic conditions pertaining to certain areas, such as neurology, psychiatry, and cancer. With this, it is harder for a genetic counselor to keep up with all the information associated with all genetic conditions, forcing them to become specialized in a certain area of knowledge. (Rom, 2006, pp. 107-108)

In this framing, the complexity of information imposes constraints on learning such that specialization becomes necessary. Specialization might subsequently generate demand for continuing professional education and learning related to genomics, as genomics may represent a new area of specialization and an outlet for thwarted career aspirations or portend additional, downstream shifts within existing specialties. It should be noted that the Rom (2006) study was completed prior to the clinical availability of genomic tests.

The Rom (2006) study demonstrated early efforts to reconcile the expanding complexities of practice, shift toward specialization, and limitations of initial training and continuing professional learning and development. "As genetic counselors work increasingly outside the scope of clinical genetic counselors, the training programs are simply unable to accommodate the educational needs of such counselors" (Rom, 2006, p. 111). Thus, training programs were called to make adjustments to accommodate the changing profession, serial innovations being a pressing factor in the attendant urgency to update training. A potential obstacle to discerning which learning strategies are most likely to be appropriate in context and content for the profession and its members was that "disagreement over the vision of genetic counseling within the profession itself creates dissonance on how to best proceed with professional development… The lack of strong leadership and internal disagreement among genetic counselors is a major finding of this study" (Rom, 2006, p. 130), which was consistent with discrepant interpretations of the impact of innovations on genetic counseling practice, ranging from paradigm shift to business as usual, as reviewed above.

The main limitation of the Rom (2006) study grew from the sampling technique: key informants were by design influential and powerful in the field, and their perspectives were further privileged by including only their views in the study and to guide further recruitment. Furthermore, the vast majority of participants identified by referral from key informants worked in New York City. Not only was this small group of professionals likely to be familiar with each other and share practice patterns as influenced by geographic location, but considering the potential diversity of practice models and perceptions throughout the United States, this sampling approach limited the scope of the study's findings. Additionally, the interview protocol was flexible such that all participants were not asked the same questions, thus answers could not be compared directly for consistency.

The above studies demonstrated that professional development and continued professional learning in genetic counseling had not been comprehensively studied. Limitations of previous research included focus on acquisition of skills and knowledge instead of overarching processes of learning and development, assumed analogy to other professions, or exclusion of genetic counselors in non-clinical roles from study participation. Additionally, the influences of contextual factors – such as technological innovations and the surrounding climate of the profession itself – were largely ignored. To in part address the limitations, research on contextual factors and their impact on genetic counselors' continued professional learning and practice was curated.

Practical Applications of Learning Conceptualizations

Professional learning and development may take many forms – formal or informal (Miranda et al., 2016), deliberate or unexpected (Zahm et al, 2016). Detailed attention to practical applications of learning conceptualizations in genetic counseling was reviewed by first examining the role of advanced degrees as continuing professional education of genetic counselors wishing to conduct professional development via formal learning. Advanced degrees as a formalized, circumscribed example of continued professional learning was the most prominent collection of cohesive research on learning in the genetic counseling literature. Alternatively, several studies made references to reflection and self-awareness as methods of professional development, hence those studies were reviewed as examples of informal learning strategies.

Advanced degrees as formal professional learning. The first appearance of the notion of advanced degrees in genetic counseling was noted in a proposal at the 1986 NSGC conference (Scott et al., 1988). This proposal sparked further, reasoned debate as the focus of a discussion at a genetic counseling education conference in 1989 (Walker et al., 1990). Discussants at the conference came to a general consensus, published as a summary article, outlined as follows:

> As the profession of genetic counseling has matured, the possibility of instituting an advanced degree, presumably a Ph.D., in genetic counseling has been raised. Much of this apparent interest has been on the part of counselors themselves, some of whom have expressed concern either over lack of opportunities for professional advancement and challenge or over the dearth of a self-generated genetic counseling literature. (Walker et al., 1990, p. 1225)

Support of a Ph.D. in genetic counseling as the advanced degree of interest was based on the opinions that less extensive training may not produce a significant difference in the genetic counselor’s knowledge base to influence practice or career development, and analogous degree programs in other professions already existed (Walker et al., 1990). Potential advantages were anticipated at the individual level and included greater respect in academia, stronger research skills, and personal satisfaction. Conversely, potential disadvantages were suspected at the profession level, such as the introduction of a hierarchy among genetic counselors, degree inflation (replacement of the current terminal degree), reduction of the available workforce as counselors opt for additional training time, and creation of a divide between theoreticians/researchers and practitioners (Walker et al., 1990). The authors also mentioned the question of demand for such a degree, which "would have to be proved before an institution would be likely to initiate and support a Ph.D. in genetic counseling" (Walker et al., 1990, p. 1226). Thus, this was the first case of extensive investigation of an advanced degree as a mechanism of professional development for the purposes of career advancement for genetic counselors. Juxtaposing this debate on additional training with theories of professionalization of the field in terms of increased knowledge requirements underlying trends toward specialization as studied by Rom (2006) raised interesting uncertainties about the form and function of ongoing professional learning for genetic counselors, particularly in response to innovation.

To ascertain genetic counselors' opinions on the issue of advanced degrees, Gaupman, Edwards, Brooks, and Young (1991) surveyed 337 of the 565 full members of the NSGC (59.6% response rate) about a potential genetic counseling doctoral degree as an extension of issues raised in the initial discussion at the 1989 conference. They found that 54% perceived a need for a doctorate in genetic counseling, 31% were undecided, and 15% thought it unnecessary. Furthermore, 44% expressed a personal interest in pursuing such a degree. "Professional recognition, a desire to specialize in a particular area, and greater depth of knowledge" were the primary reasons given for support of an advanced degree (Gaupman et al., 1991, p. 488). Interestingly, a majority believed that candidates for such a degree should be master's-trained, certified, and have some practice experience prior to enrolling (p. 491), insinuating a preference for a doctorate not as an entry-level degree but as an option for mid-career professionals. The authors reported that "the doctorate in genetic counseling was considered a natural progression within the field, which would provide increased professional recognition within the academic community and would further legitimize the profession as a distinct discipline" (Gaupman et al., 1991, p. 490). Though this study corroborated the concern previously aired by members of the 1989 education conference that a doctorate in genetic counseling could devalue the master's degree and added concern for the potential effect on salaries that the availability of an advanced degree might have (p. 491), the authors concluded that "this study revealed a strongly positive attitude, among full members of the NSGC, toward establishment of a doctoral degree in genetic counseling" (Gaupman et al., 1991, p. 488). Repeating such a study in the era of genomics would have been helpful in comparing opinions of genetic counselors more than 20 years later, and in fact, Atzinger et al. (2007) realized the benefits of additional research through their study on genetic counselors with doctoral degrees.

Walker et al. (1990), in their initial summary article, suggested additional research that might help to inform the debate about potential advanced degrees. One such suggestion was to survey individuals in the field who have already obtained an advanced degree "to determine their motivation in seeking another degree, what type of degree they chose and why and whether they would have chosen this advanced degree if a doctorate in genetic counseling had existed" (Walker et al., 1990, p. 1226). Atzinger et al. (2007) followed up on this suggestion, offering the following purpose of their study:

> to gain a better understanding of experiences, practice and attitudes of members of the NSGC who currently hold doctoral degrees in order to better understand how the development of a doctoral degree in genetic counseling might impact the field of genetic counseling and its members. (p. 224)

They began the article by offering analogies to the topic of advanced degrees in related fields such as nursing, social work, audiology, pharmacy, and psychology. The study itself consisted of structured, open-ended interviews of 31 genetic counselors who had earned a doctoral degree (51.7% of all potential participants). Topic areas of the interview were derived from literature of related fields and genetic counseling and included probes for thoughts on how their work might differ from genetic counselors with master's degrees; perceived advantages and disadvantages of having a doctoral degree; impact, if any, a doctoral degree may have had on their job satisfaction or career progression; and opinions on the development of a genetic counseling doctoral degree (Atzinger et al., 2007). Participants named advantages such as "greater knowledge and skills, performing research, additional opportunities, greater respect and recognition, tenure eligibility, and greater autonomy" (Atzinger et al., 2007, p. 230); however, disadvantages included "no disadvantages, increased time/work, MD would have been better, decreased patient contact, and decreased opportunity" (p. 230). Though insightful, this study included a naturally biased participant pool, given the eligibility criteria of having a doctorate.

Two additional pieces from the professional literature deserved mention when reviewing advanced degrees. Wallace, Myers, Heuther, Bedard, and Warren (2008) conducted a survey of thirty employers (52% of the 58 employers contacted) of genetic counselors to assess potential employability of genetic counselors with doctoral degrees. They concluded that:

> Employers overwhelmingly perceived opportunities for genetic counselors with a PhD in genetic counseling in research and academics, and acknowledged the benefits advanced degree training would bring to the genetic counseling profession, including areas in which genetic counselors have expressed dissatisfaction. In the future, employers perceive expansion in the genetic counseling profession, both in the number of practicing genetic counselors and in the genetic counseling scope of practice. The development of a PhD degree in genetic counseling is one pathway to expedite this growth process, facilitating advancement opportunities for genetic counselors. (Wallace et al., 2008, pp. 218-219)

Certainly, this was a favorable report in support of the development of a doctorate in genetic counseling, especially if expansion of scope of practice would be in the direction of specializing in new technologies. Similarly, McCarthy Veach and LeRoy (2012) offered a series of vignettes to illustrate “defining moments” experienced by genetic counselors during their careers. They included the story of Redlinger-Grosse, who branched out from “the ‘routine’ from her prenatal genetic counseling (said ‘routine’ being herself) by beginning a doctoral program in Counseling Psychology… [which] renewed her commitment to actively engage in self-reflection and to consider her patients’ individual and cultural issues” (McCarthy Veach and LeRoy, 2012, p. 166). Though Zahm found “several seasoned practitioners described wanting to develop new skills (teaching, research, etc.), new areas of specialty (such as earning a PhD or additional graduate degree” (Zahm, 2009, pp. 195-196), Redlinger-Grosse offered the first and only documented account of a genetic counselor pursuing an advanced degree as professional development which resulted in the intermingling of personal and professional development.

More recently, the conversation surrounding advanced degrees turned a corner. Following extended debate of introducing the clinical doctorate as an entry-level degree for genetic counselors, and its eventual dismissal, discussion of advanced degrees transitioned to a conversation of advanced training more generally (Nagy et al., 2015; Baty et al., 2016). The Committee on Advanced Training for Certified Genetic Counselors (CATCGC) was formed in 2012 and "[t]he intent was to explore needs for advanced training and possible training paths" (Baty et al., 2016, p. 629). The committee published an interim report of their efforts, which produced three informational grids designed to "serve as a starting point for envisioning and developing a model of advanced training and career development for genetic counselors" (Baty et al., 2016, 630). Though the grids had not been empirically tested, the CATCGC described plans to research their potential impact. This work put forth an expanded view of professional learning in genetic counseling – albeit focused on formal learning opportunities but attending to alternatives – acknowledging "advanced degrees are not the only way to obtain additional knowledge and skills. Certificate programs, continuing education opportunities and on-the-job training can also promote career advancement" (Baty et al., 2016, p. 628). In counterpoint to the focus on formal learning in the grids, the CATCGC sponsored a workshop at the 2014 NSGC annual education conference about career trajectories in genetic counseling. The workshop began with a presentation on career trajectories, proceeded to a panel of genetic counselors offering narratives of their personal career trajectories, moved to a Decision Points exercise based on the critical incident technique to facilitate identification of high and low points in one's career, and concluded with small group discussion on considerations for and challenges to participants' career trajectories. Participants were invited to submit their Decision Points worksheets to the workshop organizers for research purposes; thirteen participants donated their worksheets, and the resulting study identified and described qualitative themes regarding career high points, career low points, and transitioning between high and low points (Hippman & Davis, 2016), and complemented the practical approach of the CATCGC by sharing a constructivist perspective on philosophies of career trajectories. The study by Hippman and Davis (2016) was limited by the small number of participants, lack of identifying information about those from the workshop who did and did not donate their worksheets, and a qualitative the results from which results could not be generalized.

While the studies above explored the impact of advanced degrees, training, and trajectories on the careers of individual genetic counselors, Kenen (1997) speculated on the effect of lack of a doctorate in genetic counseling on the profession overall. In light of ties to frequent scientific innovations, her assessment of genetic counseling as an ever-evolving profession seemed prescient in retrospect.

> Periodically, the Masters level genetic counselors discuss the advisability of offering a doctorate in genetic counseling – one traditional characteristic of a profession that genetic counseling lacks. Those in favor of the doctorate believe that the Ph.D. would give them more professional recognition. Those opposed see genetic counseling as a clinical specialty and the Ph.D. as a required degree for research or high level administrative positions. As of now, the Masters level program remains the terminal degree, but whether it can remain that way in light of increased specialization, changes in types of job opportunities and increased competition for the health care dollar remains an open question. (Kenen, 1997, p. 1381)

Kenen’s (1997) view, in conjunction with the aforementioned studies, contributed to analysis of the potential value of advanced degrees from different angles, thereby characterizing the contribution of established methods of formal learning (degrees or credentials) to the professional learning alternatives available to genetic counselors as they sought to stay abreast of changes in the practice context.

Genetic counseling has diversified over time, with practitioners now working in several specializations and many taking on non-clinical roles in teaching and research

(Atzinger et al., 2007). Though genetic counselors draw on other professions such as psychology to inform practice, it stands to reason that the profession is specialized to such a degree as to merit a separate and distinct model of professional development (Zahm, 2009): "Genetic counselors (especially experienced and seasoned counselors) commented on how different the profession is, the 'growing pains' of finding their place and voice in the medical profession, and discovering similarities and differences related to the fields" (Zahm, 2009, p. 203). Research on practical applications of conceptions of learning, such as those related to a doctorate in genetic counseling, indicated that many questions persisted as to the structure and purpose of professional development in genetic counseling, and of learning in professional development. There was a limited foundation on which to build understanding of professional learning that may be directed toward maintaining expertise within circumstances of practice which constantly fluctuate.

Social professional learning. Though education at the entry level may set the tone for professional learning, learning throughout one's career might more directly result in accommodation of practice in response to innovations which subsequently arise. Examples of relevant continuing professional learning opportunities for practicing genetic counselors were found in two studies from 2011. Blazer, MacDonald, Culver, Huizenga, Morgan, Uman, and Weitzel (2011) developed a course in cancer genetics and offered it to practitioners in multiple disciplines. The course combined distance learning, in-person training, and continued online support with the aim of conveying cancer genetics knowledge and enhancing translation of this knowledge into practice. From a follow-up study with all 131 past course participants, Blazer et al. (2011) concluded that "sustained alumni participation in web-based professional development activities has evolved into a distance-mediated community of practice in clinical cancer genetics, modeling the lifelong learning goals envisioned by leading continuing medical education stakeholders" (p. 832). Also, along the lines of learning with colleagues, Dunlop, Barlow-Steward, Butow, and Heinrich (2011) facilitated peer interaction among genetic counselors in the form of group experiences with standardized patients to enhance communication skills. Evaluations were completed by 88 of the 97 participants just following the learning experience; additional evaluations targeting long-term follow-up were completed by 21 of the 38 participants who had taken a workshop prior to 2007; a focus group of seven participants was also conducted. Overall, participants stated that benefits and outcomes of participation "included facilitator feedback, actors rather than role-playing with peers and being able to stop and try doing things differently… opportunity to reflect on practice; bring focus to communication; motivation and confidence" (Dunlop, Barlow-Steward, Butow, & Heinrich, 2011, p. 217). Similar to the Blazer et al. (2011) study, evaluations highlighted the benefit of continued interactions with others for increasing translation of training content to practice (Dunlop et al., 2011). Additionally, the researchers commented that personal reflection, peer feedback, the opportunity to experiment, and enhanced self-awareness constituted the greatest gains for participants and may have been more impactful than attempting to train already skilled professionals (Dunlop et al., 2011). Both the Blazer et al. (2011) and Dunlop et al. (2011) studies exhibited the efficacy of peer interaction and feedback as a means of continued professional learning, the former toward the acquisition of scientific and medical knowledge and the latter toward enhancement of existing psychosocial counseling skills. A limitation shared by both studies was that evidence of knowledge transfer to practice was restricted to participant self-report rather than corroboration through other data sources.

The Blazer et al. (2011) and Dunlop et al. (2011) studies provided evidence of the value of interaction with peers for the professional learning of genetic counselors in response to innovation.

Experiential professional learning. In the genetic counseling literature, attention to professional development was often accompanied by reference to reflection – enacted as self-reflection or reflective practice. This close association was most prominent throughout a special issue of the Journal of Genetic Counseling (2016, Issue 25) on genetic counselor development. Callanan and Redlinger-Grosse (2016) identified reflection as a main theme or "take-a-way" of the included articles and reinforced that "through reflective practice, genetic counselors can better listen to their personal and professional experiences as integral growth points in their development" (Callanan & Redlinger-Grosse, 2016, p. 615). Indeed, evidence of reflection's potency was plentiful throughout the issue. Included therein was Miranda et al.'s (2016) report on expertise in genetic counseling, which defined self-reflection as "a willingness and openness to continuously engage in a process of critical analysis of one's thoughts and/or behaviors in order to understand motives and continually 'self-evaluate'" (Miranda et al., 2016, p. 772), and went on to align self-reflection with effective practice, particularly when genetic counselors assumed a reflective stance to "learn from situations that did not go the way they would have liked" (Miranda et al., 2016, p. 776). The definition of self-reflection was then brought to life in the personal narratives of Disco (2016) and Biesecker (2016), the latter declaring "self-reflection is critical to assessing and improving our own practice" and offering examples of reflective techniques such as recording and analyzing patient encounters independently or in the context of supervision (Biesecker, 2016, p. 623). Further, a study by Wells, McCarthy Veach, Martyr, and LeRoy (2016) on meaning for genetic counselors concluded that "intentional, focused reflection upon issues of *meaning* may mitigate risk for burnout, help counselors cope with compassion fatigue, strengthen their career satisfaction, and ultimately enhance service provision" (Wells, McCarthy Veach, Martyr & LeRoy, 2016, p. 814) and issued a call education – at graduate and continuing levels – focused on self-reflective practice centered on meaning.

Zahm et al.'s (2016) report on professional development in genetic counseling also corroborated the prominence of reflection ("participants continually identified self-reflection as critical to professional development") among genetic counselors and stipulated "*experience* in combination with *reflection upon* that experience (through introspection, self-reflection, informal discussions with colleagues, or other means) is essential to professional development" (Zahm et al., 2016, p. 830); this statement represented a step toward operationalizing the concept of reflective practice within genetic counseling beyond immediate association with self-reflection. Structured reflective practice joining primary experience and secondary reflection thereupon was previously employed by two genetic counselors during their experiences of interdisciplinary education through observation of physician colleagues and subsequent derivation of formal learning points (Mann, Taylor, James & Gaff, 2014). For others interested in adopting their unique approach, the authors endorsed "undertaking this as a reflective process" (Mann et al., 2014, p. 718).

Learning in the Current Professional Context

Several articles have speculated on the potential relationship between genetic counselors' practice and technologies (Everett, Gustafson, & Raymond, 2014; Gettig, 2010; Mills & Haga, 2014; Ormond, 2013; Weitzel et al., 2011; Wicklund & Trepanier, 2014), and this close association compelled investigation of how innovative technologies challenged genetic counselors' practice models. Previous research on genetic counselors' response to ethical and professional challenges was conducted by Bower, McCarthy Veach, Bartels, and LeRoy (2002). From focus group data in a prior study, Bower et al. (2002) developed a questionnaire and piloted it with the original focus group members as well as members of the study's advisory group; the final questionnaire was mailed to 762 genetic counselors randomly selected from the full membership of the National Society of Genetic Counselors, of which 454 responded. Participants were eligible to complete the survey if they had seen a patient in the last two years. The survey was designed to ascertain the frequency with which participants encountered certain ethical and professional challenges, elicit descriptions of particularly difficult challenges, gather possible responses to challenges, and record demographic information. Frequencies were measured on a four-point, Likert-like scale which was dichotomized during coding ("1" and "2" responses were combined, as were "3" and "4" responses). The researchers co-opted coding categories from the prior focus group study and all open-ended responses were independently coded by two researchers (Bower et al., 2002).

Relevant results of the Bower et al. study (2002) demonstrated that multiple genetic counselors experienced uncertainty ("ambiguity arising from uncertainty about outcomes, utility of information, lack of information or guidelines") and professional identity ("role ambiguity… these involved situations in which genetic counselors were unsure of their professional role") as challenges that occurred in their work (Bower et al., 2002, p. 171). Interestingly, the researchers commented on the low frequency of a theme about struggling to maintain proficiency ("difficulty keeping up with advances in genetics and/or guidelines for the application of genetics to practice" [p. 172]):

> Only one individual described a situation involving difficulty keeping up with genetic knowledge. This is surprising considering the exponential growth in genetic knowledge. Perhaps genetic counselors do not consider keeping up with knowledge to be as challenging as other types of ethical/professional issues because this is a requisite part of their daily work. It is also possible that lack of knowledge is a more objective and *temporary* dilemma with a fairly straightforward resolution (i.e. figure out what you don't know and go to a source to get the information). In the present study respondents were not asked *why* their anecdotes were particularly challenging for them. Additional research is needed to address this question. (Bower et al., 2002, pp. 180-181)

Their tentative interpretation of this finding prompted their call for further research. Finally, the researchers noted that, in response to an item inquiring about how genetic counselors respond to their professional challenges, "the fourth most frequent response for addressing dilemmas was no solution. While some participants may have simply chosen not to answer this question, others emphatically stated, 'Please tell me what to do!'" (Bower et al., 2002, p. 182). This intimated that there existed (and may still exist) an opportunity for professional learning strategies to address professional challenges such as those associated with the integration of new technologies into practice, especially if genomics challenged the "objectivity" of knowledge with attendant complexity, ambiguity, and uncertainty of interpretation and application. Furthermore, this study was conducted in 2002 and the technological landscape was significantly different, potentially limiting applicability of this study finding to a more contemporary professional landscape.

The above study was revisited and extended by Groepper, McCarthy Veach, LeRoy, and Bower (2015) in their research on ethical and professional challenges of laboratory genetic counselors. The survey from the Bower et al. (2002) study was modified and a link emailed to the NSGC listserv, indicating eligible participants as those "working in a laboratory-based role" (Groepper, McCarthy Veach, LeRoy, & Bower, 2015, p. 583). One hundred eleven genetic counselors responded with demographic information and completion of the survey. "Facing uncertainty" was the most common ethical/professional challenge, identified by 38 respondents (34.2% of the study's sample), and described further as "dilemmas in the interpretation and disclosure of an ambiguous test result" (Groepper et al., 2015, p. 585). The authors noted that the proportion of laboratory genetic counselors identifying uncertainty as a challenge was not statistically significantly different from the proportion of clinical genetic counselors doing so in the Bower et al. (2002) study. Similarly, a similar proportion of both laboratory and clinical counselors agreed that attaining and maintaining proficiency was a challenge (no statistically significant difference in proportions, at 27.0% and 21.2% respectively). The Groepper et al. (2015) was useful in demonstrating the persistence of uncertainty as a challenge for genetic counselors into the era of genomic technologies. Additionally, the inclusion of genetic counselors in laboratory roles expanded the previously narrow focus on perspectives of genetic counselors from traditional clinical working environments. While intriguing, the authors astutely shared that their findings allowed for a somewhat stilted comparison between practitioners in two different genetic counseling specialties at two different time points. Among a range of factors at play in the comparison, they intimated "the introduction of new technologies" as potentially impactful (Groepper et al., 2015, p. 595).

Following the thread of argument on the interplay of innovation, uncertainty, and learning led to examining how genetic counselors perceived the arrival of genomic technologies to practice. Genetic counselors' opinions of the integration of genomic testing were explored in a study by Machini, Douglas, Braxton, Tsipis, and Kramer in 2014.

Purposive sampling of all members of the National Society of Genetic Counselors was conducted. Two versions of an online survey tool were constructed, one for genetic counselors who work at institutions offering whole exome sequencing or whole genome sequencing (WES/WGS) and one for genetic counselors working at institutions who do not offer WES/WGS. Though they intended to employ snowball sampling to include the views of other healthcare providers, this approach was unsuccessful, thus genetic counselors were the only participants and provided 221 responses (response rate not provided). Survey responses were reviewed for common themes. Study findings indicated that many genetic counselors were uncomfortable interpreting results of WES/WGS and felt they had not received training and education needed to do so (Machini, Douglas, Braxton, Tsipis, and Kramer, 2014). Additionally, they identified multiple barriers to implementation such as no chance to offer such sequencing due to area of practice, insurance/cost concerns, and difficult interpretation of results (Machini et al., 2014). Respondents were interested in additional resources, primarily related to practical considerations around "technology/methodology used, data interpretation/analysis tools, case reports, guidelines on consent and result communication as well as ethical/counseling issues" (Machini et al., 2014, p. 501). Despite the express discomfort and obstacles, the researchers expressed that "genetic counselors are key players in the integration of WES/WGS in patient care, participating in the decision-making, consent and communication of results aspects of the process… [and] envision being involved in these same aspects of genomic testing" (Machini et al., 2014, p. 502), thus showing that genetic counselors viewed genomic technologies as falling within their professional purview.

Tomlinson et al. (2016) supplemented aforementioned barriers to implementation of WES/WGS through their interview study of 29 genetic counselors actively involved in facilitating genomic sequencing with patients. Participants were purposefully recruited due to their work with clinical sequencing projects and completed audio-recorded, semi-structured interviews by telephone about consenting for genomic testing – their approach to the process and a particularly challenging case. Challenging cases were analyzed using NVivo 10 to differentiate challenges related to patient characteristics (literacy level, expectations, contextual factors) or the process of decision-making (interpersonal interactions, questions about the utility of the testing, and discrepancy between patient and provider perceptions). Though not identified among the themes, the authors extrapolated that "the complexity of genomic sequencing, the variety and uncertainty of potential results, the broad implications of those results, and the elevated expectations of personal benefit from genomic sequencing create some new or amplified challenges for informed consent" (Tomlinson et al., 2016, p. 71). Case examples such as those analyzed through the study were put forth as a means of professional learning for genetic counselors wrestling with informed consent for genomic sequencing (Tomlinson et al., 2016)

Other technologies have impacted genetic counseling practice in recent years. For instance, testing for chromosome abnormalities – once completed by standard karyotyping (a technique for producing a picture of the structure of all chromosomes) – has improved with the introduction of chromosome microarray testing, a test with better resolution of chromosome structure which allows for detection of smaller deletions and insertions of genetic material than would likely have been undetectable by traditional testing. Bernhardt, Kellom, Barbarese, Faucett, and Wapner (2014) explored genetic counselors' views on utilizing chromosome microarray testing, counseling on uncertain results, and interest in additional education related to the technology. In-depth telephone interviews were conducted with 10 genetic counselors who previously participated in a prior study related to this testing. Interviews were semi-structured, audio-recorded, and transcribed. NVivo 10 was used to facilitate data analysis; themes emerging from the data constituted a code book. Interview responses were used to develop a survey consisting of items scaled on a 1 to 4 Likert-like scale (dichotomized during analysis) regarding interest in additional education and comfort level when counseling on uncertain results. Demographics were also ascertained. A link to this survey was posted to a discussion forum on the NSGC website and emailed to several genetic counselors directly, together gleaning 193 responses (overall response rate not provided). Participants must have counseled at least one patient on microarray testing to be eligible to participate (Bernhardt, Kellom, Barbarese, Faucett, & Wapner, 2014, p. 942).

A prominent finding of the Bernhardt et al. (2014) study was a fervent desire for additional education and training on interpreting and counseling about uncertain results. Innovative technologies detect findings about which little clinical information is known, thus hampering interpretation and decision-making via a professional challenge of the type described by Bower et al. (2002). Bernhardt et al. (2014) aptly characterized this situation as follows:

> With the advent of new genomic testing technologies, such as whole genome and whole exome sequencing, the frequency with which genetic counselors will be faced with uncertain information will increase. Paradoxically, patients may actually expect higher levels of certainty about predictions relating to health and development as they utilize new genomic testing modalities (Kenen et al 2011). (Bernhardt et al., 2014, p. 939)

Respondents in this study conveyed this uncertainty and subsequently felt hesitant about assisting patients with decision-making based on uncertain results. As facilitating patient-centered decision-making is a central responsibility of genetic counselors, the researchers paid careful attention to this concern, acknowledging that "in order to help a patient make a decision under conditions of uncertainty, the clinician will need to take it upon herself to first become comfortable with uncertainty (Braddock 2013)" (Bernhardt et al., 2014, p. 945). The findings were clear on the need for additional education: "Respondents expressed the most interest in locating resources for up-to-date information on the implications of specific insertions or deletions (96% interested), dealing with uncertainty of results (90% interested), and communicating abnormal or uncertain results to patients (88% interested)" (Bernhardt et al., 2014, p. 942). Importantly, the study emphasized the need for education at all levels of training on the technical aspects of innovative technologies as well as psychosocial components of communicating uncertain findings – both key components of a genetic counselor's practice. The authors suggested that additional information was needed to clarify mechanisms for supporting genetic counselors who are dealing with uncertainty surrounding new technologies (Bernhardt et al., 2014), yet no suggestions were made for specific educational offerings. Furthermore, though this study shed light on the reactions and learning needs of genetic counselors working in the prenatal setting, it did not explore whether genetic counselors working in other specialties (cancer, pediatric, adult, research, industry and other settings) would react similarly to new testing options.

Affirming struggles with uncertainty and responding with direction, an engaging article by Werner-Lin, McCoyd, and Bernhardt (2016) offered recommendations for counseling on chromosomal microarray testing based on literature and past professional experiences. These recommendations were framed within a professional context concurrent with the complexity of genomic technologies. Indeed, the article categorized sources of uncertainty introduced by genomics as reducible or non-reducible, scientific or non-scientific and emphasized the import of assessing both the patient's and genetic counselor's tolerances for uncertain information (Werner-Lim, McCoyd, & Bernhardt, 2016). Echoing Bernhardt et al. (2014), there was again a call for "continuing education and peer-supervision focused on communication skills and training workshops to enhance counselor confidence and to permit reflective practice" (Werner-Lim et al., 2016, p. 864). Together, these studies corroborated disconcertion in response to genomic technologies, and the immediate identification of education as remedy.

It was clear from the above studies that innovative technologies consistently disrupted the stable state of genetic counseling practice by increasing perceived uncertainty, complexity, and ambiguity in the practice landscape. Genetic counselors, in responding to their discomfort regarding these technologies, looked to learning, education, and training as potential paths to resolution of their disrupted practice. For clarification on satisfying these educational needs, Profato, Gordon, Dixon, and Kwan (2014) surveyed directors of genetic counseling training programs in the United States. Thirty-two program directors were emailed a link to an online survey containing 17 questions to gather views of the importance of incorporating genomics into the entry-level training curriculum. Those completing the survey were invited to participate in content analysis also. All responses were coded by two investigators prior to being returned to participants for additional review. Sixteen programs responded (59% response rate), with 15 stating it was important to incorporate genomics into the curriculum: "[r]espondents expressed that an understanding of and involvement in genomic medicine is necessary for genetic counseling to stay relevant as a profession as the use of genomics in medicine increases" (Profato, Gordon, Dixon, & Kwan, 2014, p. 682). Program directors appeared to assume a reactive stance toward altering training when they stated that "programs continue to change 'as needed' depending on the development of new technologies and applications and the clinical relevance of specific technologies" (Profato et al., 2014, p. 683). These adjustments occurred while maintaining a strong core of developing general skills which were likely to remain applicable (Profato et al., 2014, p. 687). In this way, program directors seemed to agree with the perspective that incorporation of genomics is more akin to an extension of current practice than to a paradigmatic shift, similar to the position taken by several authors previously mentioned (Gettig, 2010; Wicklund & Trepanier, 2014; Everett, Gustafson, & Raymond, 2014). Though this study provided insight into the views of program directors, only half of training programs existing at the time responded to the survey. Also, responses were directed at changes in entry-level training, which may differ appreciably from continuing professional learning and development interventions. Furthermore, the Profato et al. (2014) study did not address the form or content of shifts in training program curriculum in response to changes in technology.

The above studies illustrated that genetic counselors anticipated the inclusion of genomic technologies into their practice, yet there was uncertainty and hesitation surrounding this prospect. Genetic counselors desired continued professional learning and development to better equip them to meet the professional challenges posed by innovation, yet no such opportunities were described in the professional literature. Entry-level training programs acknowledged the need to adjust training models, yet the content and process of adjustment was unspecified. Additionally, examples of professional learning activities constituted by peer interaction were reported, yet not as a means for allaying concerns regarding genomic technologies.

The Role of Ambiguity Tolerance

In the aforementioned studies, evidence of discomfort in response to innovations and the uncertainty they generated implicated the need to examine responses to uncertainty, complexity, and ambiguity as a potential factor mediating professional learning of genetic counselors. The identification of ambiguity tolerance (AT) as a distinct character trait is credited to Frenkel-Brunswik in 1948. More recently, "ambiguity tolerance (AT) refers to the way an individual (or group) perceives and processes information about ambiguous situations or stimuli when confronted by an array of unfamiliar, complex, or incongruent clues" (Furnham & Ribchester, 1995, p. 179). As literature reviewed in the previous section demonstrates, evidence existed that genetic counselors perceived genomic technologies as constituting an ambiguous stimulus.

Ambiguity tolerance (AT) has been described as "a range, from rejection to attraction, of reactions to stimuli perceived as unfamiliar, complex, dynamically uncertain, or subject to multiple conflicting interpretations" (McLain, 1993, p. 184). AT has been widely researched and "is related to orientations toward other forms of perceived information inadequacy such as risk and uncertainty" (McLain, 2009, p. 985). In fact, the relationship between AT and uncertainty tolerance (UT) was formally studied: while AT influences present reactions in ambiguity, UT frames responses to future uncertainty (Furnham & Marks, 2013).

The relationships among the concepts of ambiguity, uncertainty, and complexity as pertaining to healthcare were explored in work by Paul Han and colleagues (Han, 2013; Han, Klein, & Arora, 2011; Han et al., 2017; Taber et al., 2015). Han, Klein, and Arora (2011) established a conceptual taxonomy of uncertainty as it arises in healthcare, delineating its sources, issues, and loci. They defined uncertainty as "subjective perception of ignorance", "self-awareness of incomplete knowledge" (Han et al., 2011, p. 830). Ambiguity and complexity were both situated as irreducible sources of uncertainty, meaning they cannot be addressed with additional knowledge. Ambiguity was characterized by conflicting or incomplete information and was noted to engender adverse reactions ("ambiguity aversion") (Han et al., 2011, p. 832). Complexity was constituted by multiplicity of relevant factors, producing uncertainty by obfuscating apprehension of the whole. Instead of situating ambiguity as a factor of a present phenomenon and uncertainty as of the future, ambiguity and complexity are subsumed as sources of uncertainty without reference to time. This initial taxonomy was later specified to uncertainty found in clinical genome sequencing, assuming much the same structure yet with additional layers specific to genomics, as identified through interviews with genomics experts (Han et al., 2017).

Han (2013) went on to explicate challenges of communicating uncertainty in healthcare using the above taxonomy to structure recommendations for representing ambiguity and complexity in communication of uncertainty. The work was conceptual and designed to assist clinicians in identifying and addressing uncertainty inherent in clinical care. In summary, he acknowledged

> The communication of uncertainty in clinical evidence burdens patients and clinicians alike with a set of difficult new tasks that they have been historically ill-prepared to undertake: to affirm the value of available evidence while simultaneously recognizing its inevitable limitations; to undertake decisive action

> while acknowledging all the reasons for indecision; to have faith about the rightness of one's actions and about what the future holds while affirming the irreducibility of doubt. (Han, 2013, p. 27S)

Though the taxonomy and communication recommendations were centered on uncertainty, the necessity of tolerance for ambiguity, as a source of uncertainty, was invoked as well.

Despite recognition of the shared onus of uncertainty for patients and clinicians, subsequent investigation delved into patient's perceptions of ambiguity when considering whether to receive results from genome sequencing (Taber et al., 2015). Individuals enrolled in genome sequencing clinical research studies through the ClinSeq study were invited to participate in a study attitudes toward genome sequencing; 494 (51.4% of those eligible) participated. Though many individual factors were assessed, Taber et al. (2015) analyzed the relationship between perceived ambiguity of genome sequencing and individuals' ambiguity aversion and tolerance for uncertainty. The study's premise connected uncertainty, ambiguity, and genomic sequencing.

> The science linking genetic variants to disease risk (and optimal treatment) is in a nascent stage (MacArthur et al. 2014). As such, genome sequencing may identify some variants for which there is cause for concern about disease risk but the extent and timing of the risk may be unknown and/or the implications for one's health uncertain. These factors leave open the possibility for individuals to perceive ambiguity in their results. (Taber et al., 2015, p. 716)

However, results indicated that genome sequencing was generally not perceived as ambiguous and tolerance for uncertainty did not significantly influence decisions to receive genome sequencing results (Taber et al., 2015, p.722). As there were significant findings with respect to individual ambiguity-related characteristics and inclinations with regard to interacting with genomic sequencing results, the authors suggested the following:

> Given that a patient's individual tolerance of uncertainty may influence how he or she copes with ambiguous genetic sequencing information, it may be more appropriate for clinicians to focus on addressing *responses* to perceived ambiguity

> rather than on reducing perceived ambiguity itself, and on enabling patients to adopt a thoughtful, deliberative approach to decisions about sequencing. (Taber et al., 2015, p. 726)

Considering that such an approach to decisions would likely be conducted within a shared decision-making model common in modern healthcare, a potential limitation of this study – and potential topic for future research – was the lack of attention to individual ambiguity-related characteristics of clinicians engaging with patients on topics of uncertainty and ambiguity. Efforts to investigate clinician characteristics could benefit from the use of validated measures to assess ambiguity-related traits, such as tolerance for ambiguity.

There were several available measures to assess an individual's AT. After completing comparative evaluations of measures of ambiguity tolerance, Bors, Gruman, and Shukla (2010) recommended the use of the McLain measure (MSTAT-I) to most accurately measure AT as a single trait, as it "demonstrated adequate psychometric integrity" (Bors, Gruman, & Shukla, 2010, p. 239). The MSTAT-II, a second measure developed by McLain as a shortened version of the MSTAT-I, was viewed as most appropriate when longer measures could cause mental fatigue (Furnham & Marks, 2013; McLain, 2009); it consists of 13 items rated on a scale of 1 to 7, producing a range of possible scores from 13 to 91. The MSTAT-II was chosen to assess AT in this study to reduce the burden on genetic counselors who were typically pressed for time. The MSTAT-II was previously utilized in obstetrician physicians, who were noted to have an average score of 61.6 with standard deviation of 9.9 and a range 35-87, with no significant difference in score due to common demographic factors (Yee & Grobman, 2016, p. 140).

Connection between ambiguity tolerance and genetic technologies was first and most directly made by Geller et al. (1993) in their study of how ambiguity tolerance correlated with self-described behaviors regarding genetic testing (Geller, Tambor, Chase & Holtzman, 1993). The authors framed motivation for their study as follows:

> Tolerance for ambiguity is likely to become increasingly important for physicians, as new technologies provide more opportunities for prediction, but without certainty. This is particularly true in the area of genetic testing. Despite the elegance of the technologies, many tests will leave residual uncertainties regarding future disease. The anticipated explosion of new genetic technologies provides an opportunity to study the relationship between physicians' tolerance for ambiguity (TFA) and their reported practice in an area of medicine where there is considerable uncertainty. (Geller et al., 1993, p. 990)

Physicians were surveyed about their practices of offering new genetic tests, making recommendations based on genetic testing results, and reporting distressing predictive genetic testing results, and included a modified tolerance for ambiguity measure based on Budner's work. Demographic information was also gathered. The study garnered 1140 responses among non-genetics physicians (65% response rate) and 141 responses from medical geneticists (physicians specializing in clinical genetics; 79% response rate). Results revealed that psychiatrists and medical geneticists had significantly higher tolerance for ambiguity than other medical specialties (including internists, pediatricians, obstetricians, and family practitioners). In terms of behaviors related to genetic testing, physicians with higher tolerance for ambiguity were more likely to offer new predictive genetic testing, less likely to recommend termination of a fetus found to be affected with cystic fibrosis (an inherited disease of the lungs), and less likely to omit disclosure of distressing predictive genetic test results (Geller et al., 1993, p. 997). In light of these results, the authors concluded,

> The delivery of genetic services provides a specific and timely laboratory for studying the relationship between tolerance for ambiguity and medical practice. To the extent that there is a relationship between tolerance for ambiguity and both paternalistic types of practice, and test-offering behavior, variation in ambiguity tolerance could influence not only the directiveness of physicians' counseling, but

> their willingness to incorporate new technology in their practices. (Geller et al., 1993, p. 1000)

The foresight of Geller et al.'s study in terms of interpreting the current clinical context of genomic testing was remarkable; however, the applicability of these results was limited by restricting participation to physicians and failing to include genetic counselors who, in many cases, could be expected to offer genetic testing, disclose results, and making recommendations based on those results.

Adult Education

Adult education offered many theoretical traditions and frameworks as potential lenses through which to analyze the professional learning of genetic counselors. In surveying the landscape of options with the genetic counseling literature in mind, the theories of learning from experience, communities of practice, and continuing professional learning and education were determined most applicable to this study's research questions. Therefore, the following section reviews experiential learning from the constructivist and enactivist perspectives (Fenwick, 2000) and Argyris and Schon's (1974) work on theories of action before moving into an exploration of Lave and Wenger's (1991) theory of communities of practice, followed by consideration of continuing professional learning and education as theorized by Cervero (1988) and Eraut (1994). Theoretical constructs within the adult learning literature are accompanied by empirical studies applying these theories to healthcare professionals.

Learning from Experience

Experiential learning theories have elucidated aspects and processes of learning that follow from experience: where learning occurs, how the learner engages with the experience, what roles context or emotions play. Yet experience itself is a concept not easily operationalized. Fenwick articulated the definitional elusiveness of experience in this way: “experience flows across arbitrary denominations of formal and informal education, private and public sites of learning, and compliant and resistant meaning formation” (Fenwick, 2000, p. 245). Theories of experiential learning have differed in the distinctions made among these aspects. Several theories of experiential learning were compared for insights offered when exploring the professional learning of genetic counselors in response to innovation.

Fenwick (2000) rigorously categorized theories of experiential learning, creating a useful typology. Most relevant to the present study on professional learning of genetic counselors were the constructivist and enactivist perspectives. Fenwick described the constructivist perspective as emphasizing reflection to generate learning from and in experience: “a learner is believed to construct through reflection, a personal understanding of relevant structures of meaning derived from his or her action in the world” (Fenwick, 2000, p. 248). Donald Schon, through his work on the reflective thinking of practitioners and professionals, and David Boud are central figures of the constructivist perspective. Concerns about the constructivist perspective being too narrowly focused on the individual’s intellectual processes at the expense of incorporation of contextual factors was somewhat countered by the enactivist perspective, which stipulated that learner and context emerge in concert with one another via mutual enactment. In the enactivist perspective, "learning is thus cast as continuous invention and exploration produced through the relations among consciousness, identity, action and interaction, and objects and structural dynamics of complex systems" (Fenwick, 2000, p. 262), for which professional learning in response to scientific innovation would surely qualify. Both the constructivist and enactivist perspectives were reviewed in further detail.

The constructivist approach to experiential learning. The constructivist perspective on learning from experience served as a helpful framework to assess professional learning. Boud, Keogh, and Walker (1985) described learning from experience as follows:

> Reflection is a form of response of the learner to experience… experience consists of the total response of a person to a situation or event: what he or she thinks, feels, does and concludes at the time and immediately thereafter… In most cases, the initial experience is quite complex and is constituted of a number of particular experiences within it… After the experience occurs a processing phase: this is the area of reflection. Reflection is an important human activity in which people recapture their experience, think about it, mull it over and evaluate it. It is this working with experience that is important in learning. (Boud, Keogh, & Walker, 1985, pp. 18-19)

In this theoretical structuring, an individual participated in an experience which was separate from herself. Subsequent and further thinking on the experience – reflection – occurred as she recalled the experience and her reactions to it. The constructivist perspective placed the individual – complete with a set of past experiences which significantly influenced perception and response – at the center of any reflective process which might result in learning (Boud, Keogh, & Walker, 1985). As each individual is strikingly unique on many levels, a seemingly straightforward reflective process could be expected to take as many forms as there are individuals.

A key structural feature of the constructivist view of learning from experience was separation of the initial experience from the learner who was subjected to the experience, internalized the experience so as to expose the experience itself and one's responses to the experience to reflective attention, producing learning constituted by new beliefs and/or behaviors that might then be applied to subsequent experiences. Boud, Keogh, and Walker (1985) formulated reflection as a process in three stages: "returning to the experience, attending to feelings, and re-evaluating the experience" (Boud, Keogh, & Walker, 1985, p. 21). Applying this to genetic counselors' responses to innovations, initial consideration of innovations, as described in several genetic counseling studies above, was often accompanied by remarkable emotional experiences of uncertainty and discomfort (Bernhardt et al., 2014; Machini et al., 2014; Tomlinson et al., 2016). It appeared from the available literature that genetic counselors were in the initial stages of experiencing the impact of innovation on practice and had not yet fully completed the process of experiential learning of "associating new knowledge with that which is already possessed, and integrating this new knowledge into the learner's conceptual framework… lead[ing] to an appropriation of this knowledge into the learner's repertoire of behavior" (Boud, Keogh, & Walker, 1985, p. 27). When successful, new perspectives on innovation resulting from reflection could be applied to future practice, having refined views through reflection as a form of experiential (professional) learning. This would be as the constructivists predicted:

> The outcomes of reflection may include a new way of doing something, the clarification of an issue, the development of a skill or the resolution of a problem. A new cognitive map may emerge, or a new set of ideas may be identified. The changes may be quite small or they may be large. (Boud, Keogh, & Walker, 1985, p. 34)

Many small shifts in perception via reflection could sum to a weighty and meaningful change in approach, not unlike progression through a developmental scheme, and could collectively lean against extant standard practice.

Keeping in the constructivist perspective, Schon approached reflective practice by first defining its opposite, what he called “technical rationality,” which was the thinking conducted by professionals who become “too skillful at techniques of selective inattention, junk categories, and situational control, techniques which they use to preserve the constancy of their knowledge-in-practice. For them, uncertainty is a threat; its admission is a sign of weakness” (Schon, 1983, p. 69). Some professionals might display technical rationality-type thinking when resisting changes in practice or denying uncertainty in response to innovations, both of which would be expected to limit learning. Schon (1983) pointed to a “gap between professional knowledge and the demands of real-world practice” (p. 45) to demonstrate the need for an approach that moved beyond technical rationality to embrace complexity and uncertainty. He dichotomized technical rationalists from professionals who moved beyond such expert thinking: “[t]here are those who choose the swampy lowlands... deliberately involve themselves in messy but crucially important problems and, when asked to describe their methods of inquiry, they speak of experience, trial and error, intuition, and muddling thought” (p. 43). This was the beginnings of Schon’s work on reflection-in-action, which he thought helped “practitioners sometimes deal well with situations of uncertainty, instability, uniqueness, and value conflict” (p. 50), which have been noted features of practice during shifts following innovations.

Schon’s (1983) theory of reflection-in-action described a practitioner who approached each new scenario with the assumption that it was unique, though perhaps similar to scenarios he had experienced in the past – collectively referred to as his repertoire and further defined as “the whole of his experience insofar as it is accessible to him for understanding and action” (Schon, 1983, p. 138). When encountering a new scenario, the practitioner automatically and rapidly searched his repertoire for similar scenarios.

> When a practitioner sees a new situation as some element of his repertoire, he gets a new way of seeing it and a new possibility for action in it, but the adequacy and utility of his new view must still be discovered in action. Reflection-in-action necessarily involved experiment. (Schon, 1983, p. 141)

Thus, the practitioner moved into a phase of interacting with the scenario, or "situation" as Schon called it, by experimenting with it. Put another way, "[e]xploratory experiment is the probing, playful activity by which we get a feel for things. It succeeds when it leads to the discovery of something there" (Schon, 1983, p. 145). The practitioner paid close attention to the response of the situation and assessed whether the response was expected or a surprise. Schon called this response "backtalk" and suggested it was received by the practitioner as new information "which causes them to appreciate things in the situation that go beyond their initial perceptions of the problem" (Schon, 1983, p. 148). This interchange proceeded with the practitioner experimenting and the situation responding in a continued inquiry that led the practitioner to a deeper understanding of the situation: "he does not abstain from action in order to sink into endless thought. Continuity of inquiry entails a continual interweaving of thinking and doing" (Schon, 1983, p. 280). The inquiry process, for Schon, was thus iterative and ongoing. "There is the recognition that one's expertise is a way of looking at something which was once constructed and may be reconstructed… The reflective practitioner tries to discover the limits of his expertise through reflective conversation with the client" (Schon, 1983, p. 296).

Schon's concepts of technical rationality and reflection-in-action proved useful constructs for interpreting the learning responses of genetic counselors to innovations, particularly by defining opposing ends of a spectrum of philosophies of professional learning. Schon presented a compelling version of professionalism aligned with reflection-in-action:

> The reflective contract calls for competences which may be strange to [the professional]. Whereas he is ordinarily expected to play the role of expert, he is now expected from time to time to reveal his uncertainties. Whereas he is ordinarily expected to keep his expertise private and mysterious, he is now expected to reflect publicly on his knowledge-in-practice, to make himself confrontable by his clients. (Schon, 1983, p. 299)

Schon (1983) prioritized humility and generosity, whereas medicine may be perceived as upholding the expert with proprietary knowledge. He argued that "reflection-in-action poses a potential threat to the dynamically conservative system in which [the professional] lives" (Schon, 1983, p. 332); similarly, the isolation of practice of individual genetic counselors could maintain traditional practice paradigms by preventing practitioners from conferring on various practice models (Schon, 1983, p. 333).

The constructivist view of learning from experience as defined by Boud, Keogh, and Walker (1985) and Schon (1983) thus seemed informative when viewing the professional learning of genetic counselors in response to innovation, as a template for the experiencing, reflecting, and re-evaluating a genetic counselor might conduct. Helpful as these theories were, the constructivist perspective on experiential learning has been critiqued for upholding binaries "between complex blends of doing and learning, implicit and explicit, active and passive, life experience and instructional experience, and reflection and action" (Fenwick, 2000, p. 250). To honor this critique, the enactivist perspective was incorporated as a complementary path to understanding learning from experience.

The enactivist approach to experiential learning. The enactivist perspective on experiential learning stood the learner and context as evolving in concert with one another through reciprocal determinism, with learning taking place not within the individual but through interconnections: “[t]he interpenetration of boundaries is part of the messiness of complexity and is indispensable. Cross-communications between boundaries is not accidental but part of the adaptability of the system” (Nicolaides & Yorks, 2008, p. 55). As innovations introduced unprecedented levels of complexity and ambiguity to genetic counseling, the enactivist perspective offered an alternative to the constructivist view of experiential learning. The model of learning from experience as described by Yorks in collaboration with Kasl, Nicolaides, and Wang – which they designated as whole-person learning, learning through, and a holistic approach to self-awareness, respectively – aligned with Fenwick’s (2000) description of the enactivist view of learning from experience. In this approach, “experience has both an active and a passive component, and is comprised of not just what has happened to a person, but also what a person does in interaction with the environment” (Nicolaides & Yorks, 2008, p. 52). In contrast to the constructivist view in which the learner was subjected to experience and reflected internally in response and to learn, enactivist learning was framed as active, bidirectional, co-created by the interaction of the individual and experience: “experience is the state of being in felt encounter; it is a verb” (Yorks & Kasl, 2002, p. 184). Fenwick stated of the individual and the experience that once “two systems coincide, the perturbations of one system excites responses in the structural dynamics of the other. The resultant coupling creates a new transcendent unity of action and identities that could not have been achieved independently by either participant” (Fenwick, 2000, p. 261). The enactivist perspective acknowledged that learning in a co-constructed scenario was complex and required active engagement of both experience and the individual; each necessarily influenced and shaped the other during an interaction, thus affording “equal rights to both factors in experience – objective and internal (subjective) conditions” (Nicolaides & Yorks, 2008, p. 52).

The enactivists embraced the present moment as external and internal processes occurred concurrently. Emotion was also incorporated as an equal constituent in the learning process. In the constructivist perspective, emotions were included in an individual’s response to experience; however, they were processed during rational reflection, which reified them and thus deprived them of an elemental strength. An enactivist critique of this constructivist premise suggested this treatment of emotion as representative of “the hegemonic force of an epistemology that privileges rationality… [characterizing an] Anglocentric culture as emotionally repressed and argues that overreliance on the mind limits learning” (Yorks & Kasl, 2002, p. 184). In contrast, the enactivists could counter, “by self-awareness, we mean clearer perception of one’s strengths, limitations, thoughts, beliefs, motivations, and emotions along with how one’s taken-for-granted experiences have embedded these perceptions into one’s way of being. This enhanced self-awareness provides a foundation for new behavior” (Wang & Yorks, 2012, p. 158). Emotions, such as uncertainty and discomfort, were embedded in learning similar to thought and stimuli; no internal hierarchy systematically subjected one component to assessment or analysis by another.

Though the constructivist and enactivist perspectives have been presented as distinct formulations, they likely represented an evolution. Interestingly, Donald Schon, a recognized figure in the constructivist camp (Fenwick, 2000), could be read as aligning with the holistic/enactivist perspective when he stated the following:

> In a practitioner’s reflective conversation with a situation that he treats as unique and uncertain, he functions as an agent/experient. Through his transaction with the

> situation, he shapes it and makes himself a part of it. Hence, the sense he makes of the situation must include his own contribution to it. Yet he recognizes that the situation, having a life of its own distinct from his intentions, may foil his projects and reveal new meanings. (Schon, 1983, p.163)

Perhaps this hinted at a middle ground between the two perspectives on learning from experience put forward here. Here was found the experience, the learner, and the generative interaction of the two; therein was objectivity, subjectivity, and complexity.

Argyris and Schon's models of theory-in-use. Prior to Schon's profile of an individual's reflection-in-action, he and Argyris published a framework of theories of action used by professionals during the course of their work and learning. They formulated a distinction between theories of action that were consciously acknowledged or explicated (espoused theories) and those that were not expressed yet evident through action (theories-in-use), framing it thusly:

> When someone is asked how he would behave under certain circumstances, the answer he usually gives is his espoused theory of action for that situation. This is the theory of action to which he gives allegiance, and which, upon request, he communicates to others. However, the theory that actually governs his actions is his theory-in-use; furthermore, the individual may or may not be aware of the incompatibility of the two theories. (Argyris & Schon, 1974, pp. 6-7)

As theories-in-use were understood to give rise to observable actions, and actions the means of accomplishing work, Argyris and Schon (1974) distinguished two models of theory-in-use. Model I theory-in-use consisted of a solipsistic process of identifying goals and tightly controlling the process of achieving those goals. The authors described individuals utilizing model I theories-in-use as appearing "defensive, inconsistent, incongruent, competitive, controlling, fearful of being vulnerable, manipulative, withholding of feelings, overly concerned about self and others or underconcerned about others" and learning occurring within this model as "self-sealing" (Argyris & Schon, 1974, p. 68). Most of the learning which occurred through testing behaviors was conducted privately. This description had noted analogy to the technical rationality of Schon's later work (Schon, 1983).

The authors presented an alternative theory-in-use, namely model II theory-in-use. In contrast to model I, model II theory-in-use was fundamentally social in structure. Learning conducted in model II was oriented toward quality processes rather than discrete goals, demonstrating a philosophy of means, rather than the consequentialist thinking in model I. Those utilizing model II worked through learning in close coordination with others. Control and decision-making were shared, and individuals were perceived as "minimally defensive (facilitator, collaborator, choice creator)" (Argyris & Schon, 1974, p. 87). Model II theory-in-use allowed one to stretch beyond the behavior modification of single-loop learning (adjustments in behavior or actions indicative of model I) into questioning underlying assumptions and premises of double-loop learning, and this was done publicly and with others' involvement (Argyris & Schon, 1974).

When reflecting on these theories-in-use nearly two decades after publication, the authors shared that

> Model II is more effectively learned by individuals who are grappling with current difficult problems, especially ones that have been avoided or covered up. A most powerful context for learning model II is one in which individuals identify problems that they believe are central in their lives, which they also predict are unsolvable and undiscussable. (Argyris & Schon, n.d., p. xxiv)

Within changing practice environments, Argyris and Schon (1974) suggested professionals would be best served by engaging with others to safeguard learning and decision-making processes, and presumably avoid setting goals prematurely that would be unattainable or misplaced in a newly emerging or increasingly complex or ambiguous context. It was argued that the individual, the theory-in-use, and the context of practice constantly fluctuate as

> These conditions are dynamic. An individual may become progressively less able to tolerate frustration, less able therefore to generate nonroutine behavior, and more hemmed in by his own defenses. Or he may become increasingly able to tolerate more frustration, create more opportunities for challenge in his environment, and push back the boundaries of defense mechanisms over which he has no control. (Argyris & Schon, 1974, p. 89)

Theories of action, particularly model II theory-in-use, spoke to the interconnectedness of the individual with surrounding social and contextual environments and could be viewed as approaching the co-creation aspect of the enactivist perspective of learning from experience. However, in Argyris and Schon's framework, context was construed as a separate entity and learning occurred through interaction with others acting upon the environment.

Reflection in healthcare professions. Theories of learning from experience – most prominently the concepts of reflection and reflective practice – were noted in the literature of many healthcare professions, including that of genetic counseling as delineated above. Mann, Gordon, and MacLeod (2009) conducted a systematic review of literature from 1995-2005 addressing the process or outcome of reflective practice in health professional education or practice, shaping the study's core concept of reflective practice on the work of Boud and Schon, as well as Dewey and Moon. Rationale for their attention to reflection was derived from the view that "today's health care professionals must function in complex and changing health care systems, continuously refresh and update their knowledge and skills, and frame and solve complex patient and healthcare problems. Preparing professionals who possess these capabilities is corresponding complex", with a key capability being reflective practice (Mann, Gordon, & MacLeod, 2009, pp. 595-596).

Their review yielded 29 articles which marked variety at every level: from 11 countries, including professionals and students from many healthcare professions, constructing different schema for reflection, and utilizing various educational strategies such as portfolios, mentoring, or supervision. It was noted that none of the studies assessed reflection's outcomes or influences on practice. As a whole, the authors summarized as follows:

> Reflection appears to include an anticipatory phase, where past experience informs planning; it is encouraged by appropriate supervision; it appears to occur most often in novel or challenging situations, where the professional's knowledge-in-action is not adequate to the situation. The findings of these few studies suggest that physicians and nurses use reflection to inform practice, but that it is not a unitary phenomenon either within or across individuals. (Mann et al., 2009, pp. 601-602)

Findings demonstrated clear analogy to elements of Schon's theory of reflective practice, a conclusion explicitly endorsed by Mann et al. (2009) as evidence of credence for Schon's work. Beyond that, research on reflection and reflective practice in healthcare professions lacked a coherent, codified organization, leading the authors to conclude generally that reflection was practiced by healthcare professionals, seemed multifactorial, and "amenable to development" (Mann et al., 2009, p. 610).

One study included in the Mann et al. (2009) review was a qualitative study of registered nurses' experiences of reflection. Purposive sampling was used to recruit four registered nurses for a semi-structured interview study on the use of reflection as a tool for professional development (Gustafsson & Fagerberg, 2004). An interesting finding of this study was "reflective practice involves learning alone, to see situations in different ways and from different perspectives" with targeted attention to tasks and behavior (Gustafsson & Fagerberg, 2004, p. 275), a description commensurate with Argyris and Schon's (1974) model I theory-in-use with single-loop learning. Additionally, while reflection was felt by participants to be impactful for their professional growth, they could not ascertain specific effects of reflection on their work and development (Gustafsson & Fagerberg, 2004). This was in keeping with Mann et al.'s (2009) observation that "reflection, and its role in learning, may not be obvious to learners; it may also be a tacit process in experienced practitioners" (p. 614). Taken together, the multiplicity of perspectives on, yet dearth of appreciable, practical outcomes from, reflective practice in health care professions demonstrated remaining opportunity for fulminant utilization for professional learning and development.

While Gustafsson and Fagerberg (2004) explored nurses' experiences of reflection as naturally occurring in the course of practice, Sim and Radloff (2008) developed and piloted an online module designed to increase participants' ability to engage in reflection, thereby designating reflective practice as a skillset to be developed. Their research consisted of two phases. The first phase served as needs assessment to inform development of the module; a literature review, national survey of radiographers and radiation therapists, and interviews with "Heads of Clinical Departments" were conducted. The second phase included twice piloting the resulting online module with a total of 26 participants; pre-, mid-, and post-module surveys, participants' postings to the online forum, and learning portfolios were collated and analyzed to determine if the module's objectives were met. Findings supported the efficacy of online learning for supporting development of reflective practice in medical radiation science practitioners (Sim & Radloff, 2008).

Literature in healthcare professions on reflective practice was found to span views of reflection as both natural perspective-taking and a specific skill. In a commentary of reflection which delved into educational theory, Murdoch-Eaton and Sandars (2014) merged these two perspectives, arguing reflection was a "way of thinking about productive work, not a strategy or technique" (p. 279). They expanded as follows:

> Reflection is a natural process, but like most processes, needs personal development of skills, including recognition of a prompt that stimulates reflection. This prompt is likely to be at moments of uncertainty, especially when there is an associated feeling, such as frustration or anger. (Murdoch-Eaton & Sandars, 2014, p. 282)

Acknowledgment of uncertainty as a trigger for reflection echoed the unanticipated, unexpected, or otherwise surprising circumstantial elements which inspired reflection as noted by Mann et al. (2009).

Communities of Practice

How did the adult learning theories of communities of practice shed light on strategies for continued professional learning and development for genetic counselors' responding to genomics? In general, "empirical research has demonstrated that effective [professional learning] continues over the long term and is best situated within a community that supports learning" (Webster-Wright, 2009, p. 703). Additional attention was paid to the influence of innovation, defined as a contextual factor that influenced a community of professionals to shift current practice models. Especially relevant to concerns surrounding genomic technologies was the following comment on change:

> Change has always been part of being human, but the increasing pace and breath of the current 'rapid and sweeping' change have been commented on in relation to the need to keep learning (Knapper & Cropley, 2000). Uncertainty and complexity, rather than change per se, have been highlighted as the crux of difficulties professionals face (Barnett, 2004). (Webster-Wright, 2009, p. 719)

Because uncertainty from innovative technologies was raised by genetic counselors and they were consequently inclined toward education as a potential solution, the idea of uncertainty within communities of practice warranted consideration and was explored in studies of adult learning similar to the tack taken for the genetic counseling literature.

Lave and Wenger's theory of community of practice. The concept of community of practice began with the work of Jean Lave and Etienne Wenger as they researched modern forms of apprenticeship and attended to the learning that individuals engaged in while seeking to attain professional competence and expertise (Lave & Wenger, 1991). "The term community of practice was coined to refer to the community that acts as a living curriculum for the apprentice" (Wenger, 2011, p. 4). Lave and Wenger (1991) noted that new members of a profession learned via legitimate peripheral participation, which consisted of actively engaging with a community of practitioners, first by observing, then by taking responsibility for low-stakes tasks under supervision. At this point, new members were working on the periphery of the profession, but they performed legitimate work – they were already actively engaging in activities within the scope of practice, the relevant purview of the profession. Eventually, new members took on progressively more advanced tasks and finally garnered professional competence as the skills, knowledge, and attitudes germane to the profession were gained. Not only was an individual member's status in flux based on growing expertise, so was the state of the community as new members joined and old members stepped out. Given this fluidity, Brown and Duguid (1991) suggested that "through their constant adapting to changing membership and changing circumstances, evolving communities-of-practice are significant sites of innovating" (Brown & Duguid, 1991, p. 41).

As an extension of this work, Wenger (1998) researched the social structure and work-based functioning of a medical claims processing unit, and thereby arrived at a detailed construct of community of practice (Wenger, 1998). With refinement over time, he came to the following succinct definition: "communities of practice are groups of people who share a concern or a passion for something they do and learn how to do it better as they interact regularly" (Wenger, 2011, p. 1). Communities of practice were not restricted to professional work; indeed, they could be found in any aspect of activity in which people learn and grow through joint endeavors. However, Wenger focused on communities of practice as context and facilitator of continued professional learning, a perspective which was thought to contrast or complement the traditional, didactic approach to professional learning (Wenger, 2011).

Learning in communities of practice was described as a process of coming to understand how competence was characterized by a group of people, and then balancing the social construction with one's personal experience (Wenger, 2000). This process of seeking equilibrium between social and individual perspectives was mediated by three components of a community of practice: joint enterprise (an agreed upon goal or endeavor), mutuality (bidirectional interactions and participation), and shared repertoire (a collection of shared resources and strategies) (Wenger, 1998, 2000). When these components were present and active, communities of practice were "important social units of learning even in the context of much larger systems, ... constellations of interrelated communities of practice" (Wenger, 2000, p. 229). In the context of professional practice, one might engage with a local community of practice on a daily basis, then occasionally attend a regional gathering of work units to add another community of practice, and subsequently attend a national convention adding yet a third level. These communities could be layered upon one another, interconnected and reciprocally influential in ways reminiscent of the enactivist perspective on learning from experience (Fenwick, 2000), social in the manner of model II theory-in-use (Argyris & Schon, 1974). For practitioners engaged with communities of practice, then, "their professional development and the development of the practice go hand in hand: the identity of the community as it evolves parallels the evolution of their own identity" (Wenger, 2000, p. 241); the collective understanding of competence and the lived experience of individuals would be continually reconciled.

Communities of practice in healthcare. To assess the applicability of theories of community of practice to genetic counseling, a search was conducted for studies of communities of practice in healthcare. A systematic review of the literature on communities of practice in healthcare was conducted by Ranmuthugala et al. in 2011. The authors noted exceptional diversity in the aims, memberships, and structures of communities of practice found in the healthcare setting. They sorted 33 eligible studies into categories of communities of practice which were multidisciplinary/multi-institutional (n=25), those which were single profession/single institutional (n=6), and those which represented reviews (n=2). In assessing trends in this set of studies, the researchers noted that studies published earlier in their established timeframe were more likely to describe community of practice as supporting learning and exchange of ideas; studies published later used communities of practice as an intentional intervention designed to change practice in some way (Ranmuthugala et al., 2011, p. 273), indicating that the concept had more recently been appropriated to name an intentional, socially-based learning tool rather than an organically arising set of interactions. In light of the variability in their sample, Ranmuthugala et al. (2011) stipulated that "future research needs to take into consideration this complex and varying nature of [communities of practice] and adopt other methods more suitable for evaluating complex programs in healthcare" (Ranmuthugala et al., 2011, p. 287). This study provided a useful overview of research of communities of practice enacted in the healthcare setting.

One of the studies reviewed by Ranmuthugala et al. (2011) targeted small groups of physician colleagues that met regularly to discuss practice issues. Pereles, Lockyer, and Fidler (2002) explored the perceptions of small group members via semi-structured interviews. An initial focus group of three small group members who served as facilitators informed the development of a semi-structured interview protocol, which was then piloted by five physicians. The final protocol was used to interview 22 group members and 10 group facilitators of long-term physician peer groups who were recruited via convenience sampling. The researchers used a constant comparative method for data analysis, recruiting until no new themes arose. Draft manuscripts of the interviews were returned to participants for comment. The researchers subsequently compared participant experiences of these small groups with Wenger's description of communities of practice (Pereles, Lockyer, & Fidler, 2002).

The main outcome of these groups was thought to be improvement of practice, brought about by activities that fostered reflection and dialogue (Pereles et al., 2002). Interestingly, but perhaps unsurprisingly, small group activities prompted change, but of a particular type and by a distinct process:

> Changes had to be consistent with the physician's beliefs, and they needed to be relevant and practical… For most physicians, adoption was a staged process in which they assessed the change, weighed the evidence for the change, and reflected on how it would be applicable to their own practice… Others started changing by trying the new idea out for a period of time to see how it works. The implementation of

> change often occurred slowly and incrementally with assessment and reassessment. (Pereles et al., 2002, p. 210)

Despite support from colleagues in the form of feedback, discussion, and collaborative review of available evidence – which might have been assumed to facilitate the risk-taking that chance inevitably entails – physicians were slow to make slight changes. This study did not explore factors contributing to this process of shifting practice, nor the mechanics of learning underlying these changes, though there was an apparent tension between individual and social interpretations of changes to be made, consistent with Wenger's (2000) characterization of communities of practice as a forum for contesting views of competence.

Pereles et al. (2002) described the facilitator role as having many, varied responsibilities and was noted to be integral to the group's efficacy, productivity, and continued functioning. The researchers determined the small groups had features of communities of practice but did not quite achieve the same elevated level of collaboration. However, group cohesion was enhanced in those groups in which members were partners in the same medical practice and shared patient care responsibilities (Pereles et al., 2002). The researchers concluded small groups were effective in initiating change, but more research was needed to identify approaches for strengthening such groups into communities of practice. The Pereles et al. (2002) study was helpful in analyzing spontaneously arising practice groups; however, the interactions among group members occurred separately from the daily practice setting, thus findings were viewed as more representative of a community of practice as intervention than situated occurrence.

Kitto, Grant, Peller, Moulton, and Gallinger (2017), in their study of hepatobiliary-pancreatic surgeons in Canada, wrestled with the friction between naturally occurring communities of practice and an administratively sanctioned community of practice. Their qualitative descriptive case study used snowball sampling to recruit 17 participants for semi-structured interviews; document analysis was also used to analyze official records related to the sanctioned community of practice (Kitto, Grant, Peller, Moulton, & Gallinger, 2017). There were noted to be large variations in members' understanding of communities of practice, multifactorial influences on participation, and discrepancies between the structures and functions of localized, naturally occurring communities of practice and expansive, administratively sanctioned community of practice: "This 'meta'- CoP was engineered by an organization (CCO) that was external to the day-to-day operation of the micro-CoPs located in local hospital systems which were loosely connected by the idiosyncratic surgical networks that were operating around the province" (Kitto et al., 2017, p. 14). This study was the only one to examine both naturally occurring and interventional communities of practice, as well as interaction between them.

In contrast to studies of communities of practice that arise naturally, Landeen, Kirkpatrick, and Doyle (2017) examined a community of practice intentionally designed and implemented to promote professional development of members through practicing research. A community of practice was formed for nurses interested in conducting research on hope; the community was active for 13 months, with seven members at the start and four by the end of the timeframe. Landeen et al. (2017) interviewed five participants, collated and analyzed the interview transcripts and observations of community operations and interactions. The community of practice was described as resource intensive and low-yield with respect to completed research projects (one only project was completed during the duration of the community of practice), yet analysis of interviews and observations noted that participants valued feedback and support from peers, as well as working to enhance research skills as a group (Landeen, Kirkpatrick, & Doyle, 2017). This suggested that communities of practice could be effectively and intentionally established to aid professional development of healthcare professionals, though the sample size was limited and focus of the shared enterprise fairly circumscribed.

A similar intention to enhance professional skills was the impetus behind a community of practice for physiotherapists as examined by McCreesh, Larkin, and Lewis (2016). Sixteen physiotherapists organized a community of practice around skills for treating shoulders. They met seven times over the course of nine months, to review articles, develop a website for information-sharing, and craft a protocol for shoulder therapies (McCreesh, Larkin, & Lewis, 2016). Twelve participants were interviewed to explore experiences of the communities of practice; they noted that, contrary to the expected motivation of skills improvement (which was mentioned by four participants), most (nine participants) participated in the community of practice for peer support and collegial interaction (McCreesh et al., 2016). The authors concluded this group adhered to the definition of a typical community of practice due to "learning together through peer support, knowledge sharing through mutual interaction in the journal clubs and dissemination through the website, and knowledge creation, through development of new resources" (McCreesh et al., 2016, p. 6). Indeed, evidence of joint enterprise, mutuality, and shared repertoire (Wenger, 1998) was found, further supporting community of practice as a means of promoting professional development.

Swan, Scarbrough, and Robertson (2002) used a case study approach to analyze a community of practice developed as a result of the business strategy employed by a medical product development company. The company sought to create communities of practice to support the introduction of a novel approach to treating prostate cancer. The company accomplished this by

> developing social networks which were linked to the new medical and organizational practices required for the innovation. In this way, they sought to exploit both the performative qualities of the community of practice in relation to the sharing of knowledge, and its associated discursive qualities of consensus and solidarity in relation to mobilization of commitment (Gherardi et al., 1998). (Swan, Scarbrough, & Robertson, 2002, p. 491)

This strategy aimed to bring about a shift in practice to create a market for their product, which was more in line with the description of communities of practice as an intentional intervention rather than a spontaneously occurring social construction (Kitto et al., 2017; Pereles et al., 2002) or support for development of practitioner's competence (Landeen et al., 2017). The researchers commented on the appropriation of the concept: "critically, a discourse of 'community' was employed as a rhetorical device to mobilize support for community building" (Swan et al., 2002, p. 488). This framing of communities of practice, though distinct from the original description by Wenger, can be found in other research in the healthcare setting such as the following study.

Barwick, Peters, and Boydell (2009) analyzed the role of an intervention designed to provide practitioners with a community of practice resource to support the implementation of a new clinical tool, an evidence-based assessment for children with functional impairment. A variety of measures were used to assess contextual factors (modified organizational readiness for change scale), practitioner attitudes (self-reported practice change questionnaire, measure of satisfaction, reported use of resources) and knowledge (content knowledge questionnaire), and practical application of the new tool (number of uses of the tool in practice). Participants were randomly assigned to support by community of practice or practice as usual groups. Organizations introducing the clinical tool were invited to participate in the study; within the participating organizations, 92 children's mental health employees, who were tasked with utilizing the clinical tool, were eligible, of which 37 completed consents. Thirty-four participants completed baseline assessment and 20 completed assessments at the 12-month follow-up time point. The community of practice support was offered once every two months over one year. Participants attended an average of 3.7 community of practice sessions (Barwick, Peters, & Boydell, 2009).

Community of practice participants were significantly more satisfied with supports and resources provided to facilitate incorporation of the new clinical tool (Barwick et al., 2009). There was no difference between the two groups in terms of self-reported practice change as both groups reported notable change (Barwick et al., 2009). Interestingly,

> Although practitioners supported by the community of practice did not report their practices to have changed any more than their colleagues in the practice as usual environment, they did demonstrate greater use of the tool in the real world practice context. (Barwick et al., 2009, p. 25)

Potential confounding factors of organizational readiness for change, participant self-reported work stress, and participant role overload were analyzed and found not to differ between the community of practice and practice as usual groups. The researchers concluded that communities of practice can be deployed deliberately to support knowledge exchange among providers as they incorporate new tools into practice (Barwick et al., 2009).

The Barwick et al. (2009) study supported the utility of situated learning in the professions in service to practice change: "While clinicians can learn the rudiments of an intervention in training, it is in the practice context that they will develop their knowledge and begin to shift their approach" (Barwick et al., 2009, p. 17). Similar to conclusions drawn by Ranmuthugala et al. (2011) and Pereles et al. (2002), Barwick et al. (2009) viewed training for change as a protracted, complex process which required constant support and connection to practice (Barwick, Peters, & Boydell, 2009). They eloquently concluded that "methods of teaching evidence-based practice need to change, to become more rooted in the practice environment and to be situated within a community of learners" (Barwick et al., 2009, p. 17). However, the study had several limitations that prevented its direct analogy to a similar line of inquiry for genetic counselors, namely that the practitioners were children's mental health workers, the tool was an assessment, and the sample size of the study was small with moderate attrition.

Two studies specifically analyzed virtual communities of practice for healthcare providers. Mather and Cummings (2014) studied a virtual community of practice for senior nurse leaders who served as clinical supervisors. They disseminated an online survey to gather Likert-scale responses to questions on opinions of virtual communities of practice. Results suggested that approximately three-fourths of supervisors would utilize a virtual community of practice to interact and share information with other supervisors and the sponsoring institution (Mather & Cummings, 2014), thus employing virtual communities of practice "as a strategy for workforce development of clinical supervisors in healthcare environments" (Mather & Cummings, 2014, p. 107). Ikioda, Kendall, Brooks, De Liddo, and Shum (2013) seemingly agreed with this conclusion and proposed use of the community of practice model in the virtual space: "online technologies have facilitated the development of Virtual Communities of Practice (virtual CoPs) to support health professionals collaborate online to share knowledge, improve performance and support the spread of innovation and best practices" (Ikioda, Kendall, Brooks, De Liddo, & Shum, 2013, p. 174). The Ikioda et al.

(2013) study investigated factors that influenced participation in virtual communities of practice. They provided rich description of a virtual community of practice for health visitors – qualified nurses and midwives who pursue additional training to work as community public health nurses. Key facilitators of a vibrant community of practice included: larger memberships, particularly a regular influx of new users, increased online interactions and contributions; site moderators fostered connection among other users; the role of observers and passive participants who do not post or contribute warranted additional research; and topics had to be relevant to daily practice and were more impactful if suggested by participants themselves (Ikioda et al., 2013).

Research on communities of practice in healthcare demonstrated that the community of practice concept had been explored in the healthcare setting and within several professions. Furthermore, most of this research deployed communities of practice as interventions to bring about pre-determined shifts in practice in a directive stance inconsistent with Wenger's (1998) original description in which communities of practice arose organically and evolved, and as such, were resistant to external intervention or management. Additionally, much of the literature on communities of practice in healthcare was not situated in the practice setting, but instead introduced as a forum for interaction of professionals separate from their daily work.

Continuing Professional Education

Though intertwined or addressed interchangeably, continuing professional learning and continuing professional education are two distinct aspects of the growth and development of professionals. The following definitions distinguished the two:

> Learning is a personal, emotional, and cognitive act, that results of which are unique to the individual… We define learning as 'the ways in which individuals or groups acquire, interpret, reorganize, change, assimilate, or apply related clusters of information, skills, and feelings. Learning is primary to the way in which people construct meaning in their personal and shared organizational lives' (Marsick, 1987, p. 4). Although learning is unique to the individual or group, others may try to shape and influence that learning. Any deliberate, planned effort to do so is what we call education. (Baskett & Marsick, 1992, p. 3)

This study focused on the professional learning of genetic counselors, their experiences of encountering new information, making sense of it, and acting on acquired understandings, all in the context of practice. Yet continuing professional education was always near at hand, as evidenced by analogy of this study's approach to Cervero and Daley's (2016) description of continuing professional education:

> In an evidence-based approach, professionals study the latest research in their professional area, decide how to implement that in their practice, make changes in their performance, and then document the results… [this approach] could incorporate formal CPE, or it could be a completely self-directed process for the professional. (Cervero & Daley, 2016, p. 16)

As connection between professional learning and continuing education was assumed to be strong, and indeed was demonstrated to be so in the literature, both topics were explored. The writings of Ronald Cervero and Michael Eraut, who both assumed detailed perspectives on professional education and learning and made suggestions to professionals, framed exploration of this literature. Additional themes from the continuing professional education and healthcare literatures are included by reference to these writings.

Cervero's functionalist viewpoint of continuing professional education. Ronald Cervero has written extensively on continuing education in the professions. A main contribution of his work stemmed from his categorization of viewpoints on how professions relate to society, or as he described it, the social context of continuing professional education. He constructed three distinct viewpoints: functionalist, conflict, and critical. The functionalist and critical viewpoints were assessed as having the greatest apparent applicability to analysis of the genetic counseling profession and are therefore described below.

Within the functionalist viewpoint, Cervero posited professions had a specific and concrete purpose within society and professionals benefited from relatively low levels of complexity and ambiguity in the practice scenarios they navigated. Professional issues and problems were straightforward and typically corresponded to core strategies or skills that a professional might employ to bring about a socially desired end. Continuing education for professionals in this type of practice setting “performs the instrumental function of helping professionals provide higher quality service to clients by improving their knowledge, competence, or performance” (Cervero, 1988, p. 25). Professional learning and education in the functionalist viewpoint were framed as transactional – knowledge and skills could be directly relayed to practitioners who might then immediately and with a high degree of accuracy apply their learning to successfully improve practice.

The update model of continuing professional education. Cervero’s (1988) functionalist viewpoint had specific implications for continuing professional education: that it relays concrete knowledge and skills relevant to the specific, ascertainable challenges of practice. Cervero (2000) and Mott (2000) summarized the philosophy of such education by reference to Nowlen’s Update Model, with reference to Schon’s (1983) perception of “the deeply embedded view that professional practice consists of instrumental problem solving made rigorous by the application of scientific theory and technique” (Cervero, 2000, p. 8). The update model revealed most continuing education endeavors package and transfer objective information to professionals who then readily apply the information to their work.

Though seemingly streamlined and rational, the update model "fail[ed] to account for the subjective, social, and negotiated aspects of knowledge in professional practices that are complex, indeterminate, and value-laden" (Mott, 2000, pp. 24-25). Dirkx, Gilley, and Gilley (2004) further defined the update model as focused on "increased mastery in and control over one's practice as illustrated in medicine" (Dirkx, Gilley, & Gilley, 2004, p. 37); evidence of the update model's pervasiveness in healthcare continuing professional education was noted by Schostak et al. (2010) in their study of continuing professional development of physicians. Yet Mott (2000), Dirkx et al. (2004), and Webster-Wright (2009) together demonstrated enduring awareness that information and knowledge conveyed by continuing education offered within the update model is speedily moot, compromised by the rapid rate of change in many professions. More recent publications illustrated an adjustment of language, switching "information" for "content" as the crux of continuing professional education at the expense of attention to enhancing learning, yet confirmed dominance of the update model as the philosophical foundation upon which most continuing professional education continues to be based (Coady, 2015, 2016; Webster-Wright, 2009).

Continuing professional education to regulate practice. In addition to directing the informational focus of continuing professional education, the update model also informed the application of continuing professional education to regulate professional practice. "The need for continuing professional development (PD) to maintain high-quality practice is widely identified as an implicit responsibility of professionals today, reinforced by explicit requirements of professional standards and registration procedures" (Webster-Wright, 2009, p. 702). If the premise that competent practice required updates of information or content provided by continuing professional education in direct and uncomplicated ways was granted, the conclusion which followed was that professionals could be held responsible for upkeep of professional competence accomplished through regular attendance at continuing educational events. "Increased use of continuing education as a basis for relicensure" (Cervero, 2000, p. 7) was offered as plain evidence of regulation of professionals' practice by prescribing the content and amount of continuing professional education required for credentialing (Coady, 2016, p. 91).

Consideration of registration, licensure, and other forms of credentialing as systems regulating professional practice was enhanced by a compelling vignette of a healthcare appointment as offered by Wilson (2000) to illustrate how systems, not individuals, provided services; "The autonomy of the individual professional expert, as traditionally based on professional knowledge and skill, is being superseded and undermined by the growing dominance of expert systems" (Wilson, 2000, p. 76). Wilson (2000) argued a spectrum of means by which systems have overtaken professionals' autonomy with respect to practice, including "the rapid replacement of professional self-regulation with state mandated regulation" (p. 73) with respect to ongoing professional development. In this framing, self-determination of learning needs and responses are superseded by relicensure requirements for certain types and amounts of continuing professional education, thereby depriving the professional of the chance to assess and address personal competence.

***Outcomes of continuing professional education*.** The transactional format of continuing professional education enacted from the update model lent itself to research on outcomes. Webster-Wright, in conducting a literature review of all empirical research on professional development published between April 2006 and March 2007 irrespective of profession, noted that research on professional development "focuses on specific factors affecting PD (the program, learner, or context) rather than studying the holistic, situated experience of learning" (Webster-Wright, 2009, p. 711), which helped to explain slants toward atomized outcome measures such as knowledge factors, skill levels, particular attitudes, and specific measures of quality patient care.

Cervero, partnering first with Umble (1996), then Robertson and Umble (2003), and finally Gaines (2014), assessed the efficacy of continuing education in healthcare professions by collating research syntheses of relevant empirical studies. Altogether, their analyses included 38 systematic reviews which collectively indicated that continuing medical education improved physician knowledge, skills, and attitudes. While their findings demonstrated definitive efficacy of continuing medical education with respect to professionals' attributes (knowledge, skills, attitudes), educational activities were not found to consistently impact patient or practice outcomes. Differential effects on performance and clinical outcomes were corroborated by research from within healthcare professions. Bluestone et al. (2013), in an approach similar to that of Cervero's approach, synthesized 37 systematic reviews and 32 randomized controlled trials of studies on efficacy of in-service training for healthcare workers and concluded "very limited and weak data that directly links CPE to improved clinical practice outcomes" (Bluestone et al., 2013, p. 24). Clark, Draper, and Rogers (2015) – as background for their study on strengthening the connection between education and practice – found "insufficient convincing evidence to demonstrate that investment in CPE has a tangible impact on practice and patient care" (Clark, Draper, & Rogers, 2015, p. 389). And approaching efficacy from a different angle, Légaré et al. (2015) sought to examine and categorize by Bloom's taxonomy 404 learning objectives from 110 continuing professional education activities conducted between November 2012 and March

2013. The vast majority of objectives targeted cognitive factors, with 70.8% of objectives aimed at the knowledge, comprehension, and application levels of Bloom's taxonomy, collectively. The authors intriguingly commented that

> Although at this level participants are theoretically able to comprehend and apply what they know to a given situation, it is important to note that these skills may not equip health professionals to differentiate old practices from new ones (analyze) or critique them (evaluate) in order to plan (synthesize) and implement new clinical behavior, which should be the main goal of CPD activities. (Légaré et al., 2015, p. 201)

The above assessments of continuing professional education conducted within healthcare professions – presumably crafted in keeping with the update model and potentially applied toward requirements for credentialing – suggested that education was effective at influencing professionals yet not potent enough to influence to practice.

With improvement of practice as the express purpose of continuing professional education (Daley & Mott, 2000; Mott, 2000), lack of evidence of altered outcomes in practice and clinical care indicated discrepancy between intent and impact. Webster-Wright pointed to assumptions underlying studies on professional development as contributing to the perceived shortfall of continuing education and its failure to impact practice, particularly that the complex phenomenon of professional learning could be subdivided into a collection of measurable "factors" (p. 714). She instead called for research pursuing a holistic view of learning that respected the complexity of each professional's experiences (Webster-Wright, 2009, p. 714). Several authors echoed the complexity of professional practice, exacerbated by rapid change and innovation (Cervero, 2000; Mott, 2000; Wilson, 2000). Further, Mott (2000), by synthesizing views of Schon and Cervero, purported "the challenges and complexities of practice itself, and reflection on these challenges and complexities, are the richest source of learning for the professional" (p. 29), yet sources of learning which would escape detection by existing research methods.

Cervero's critical viewpoint of continuing professional education. As a comprehensive framework of continuing education eluded researchers, Cervero (2000) was compelled to comment that there was no "recognizable picture of a system of continuing education that is effective in today's complex world" (Cervero, 2000, p. 4). In his original formulation of the position of profession's in society, the functionalist viewpoint was predicated on predictable, manageable contextual factors. In the presence of ambiguous factors in constant flux, Cervero posited that professions assumed a critical stance in society, in the sense of not merely responding to problems but rather taking an active role in framing problems to be solved through practice. Invoking Schon's characterization of reflection in action, Cervero described professional actions within the critical viewpoint.

> In the swamp the practitioner must find or construct problems from ambiguous situations. Thus, problem setting rather than problem solving is the key to professional practice. Practitioners are always in a dialectical relationship with problems, which are characterized by uniqueness, uncertainty, or value conflict. (Cervero, 1988, p. 31)

In this scenario, the professional's work lies not in being a technician (matching existing problems with known solutions), but in being something of an artist, creatively interacting with challenges so as to work with and through them. This interaction is not unlike the co-construction of individual and context highlighted by theories of learning from experience in the enactivist thread (Fenwick, 2000; Nicolaides & Yorks, 2008).

Cervero endorsed the critical viewpoint of professions in society and further explicated implications for professionals as learners within such a system of problem-finding. Making connections to Glaser's schema theory and Schon's reflection-in-action, Cervero argued that professional learning was constituted by growing and cultivating a store of understandings (a.k.a. schema or repertoire to Glaser and Schon, respectively). "New knowledge structures are created through everyday experience" (Cervero, 1988, p. 41) as these experiences provided opportunities for a professional to frame and reframe problems. Storing various permutations of past problems and their framing created a repertoire of past experiences which they could then apply to emerging scenarios and current actions.

This view of professional learning had direct implications for professional education: "the primary goal of continuing education should be to improve professional artistry or the professionals' ability to operate in the indeterminate zones of practice" (Cervero, 1988, p. 54). Unlike update models of professional education that focused on relaying static content, Cervero put forth strategies for professional education that acknowledged the complexity and ambiguity of practice and created conditions in which professionals could simulate and experiment with problem-posing, "helping learners become researchers of their own practice" (Cervero, 1988, p. 56). He specifically mentioned Glaser's case analysis approach and Schon's description of coaching.

Effective continuing professional education – practice-based, ongoing, interactive. Authors in the adult education and healthcare professions have sought to identify characteristics of effective continuing professional education (Table 1). Mott (2000) listed dynamic, authentic, practice-based, collaborative, future-orientated as common themes among models of continuing professional education found in the adult education literature. Robertson, Umble, and Cervero (2003) found continuing professional education that was ongoing, interactive, contextually relevant, and based on needs assessments as most effective based on synthesis of systematic reviews of offerings in healthcare professions. Webster-Wright's (2009) enumerated professional education that was continuing, active, social, and related to practice as realistic. Through analysis of in-service training for healthcare professionals, Bluestone et al. (2013) remarked that education conducted through multiple techniques, over longer timeframes, prioritizing application, and being interactive was more likely to influence practice behaviors. Cervero and Gaines (2014), in their updated synthesis of systematic reviews of continuing professional education in healthcare, verified the importance of interactive approaches using multiple methods and exposures over longer time periods, with focus on affecting outcomes important to participants, as the most valuable features. And most recently, Cervero and Daley (2016) summarized perspectives on continuing professional education in the adult education literature and foregrounded evidence-based, interdisciplinary, technologically sophisticated professional education connected to practice as indicators of effectual approaches to helping professionals learn. While each list in unique, the most common qualities of effective continuing professional education were that it be practice-based, ongoing or iterative, and interactive.

Table 1

Comparison of Characteristics of Effective Continuing Professional Education

Reference	**Practice-based**	**Ongoing**	**Interactive**	*Perspective*
Mott, 2000	X			*Adult education*
Robertson et al., 2003		X	X	*CPE in healthcare*
Webster-Wright, 2009	X	X	X	*Adult education*
Bluestone et al., 2013		X	X	*Training in healthcare*
Cervero & Gaines, 2014		X	X	*CPE in healthcare*
Cervero & Daley, 2016	X			*Adult education*

Context of continuing professional education. That effective continuing professional education should be tied prominently to practice scenarios and settings seemed fitting given extensive attention in the adult education literature to the indivisibility of context from professional learning. Knox (2000) suggested "challenges and changes in the workplace are sources of learning goals and activities, as well as spurs to participation in continuing education activities" (p. 18). With practice as potent instigator of learning – topically and motivationally, several authors argued for altered philosophies of continuing professional education and reframing of its goals and implementations. In the same issue of *New Directions for Adult and Continuing Education* (Number 86, 2000), Mott and Daley outlined how attention to context required a systems approach to continuing professional education; if indeed "professionals are individuals, influenced by their environments, self-images, roles, and values… practice[ing] in complex networks of interdependent systems" (Mott, 2000, p. 25), continuing professional education must "include a constructivist view of learning created by linking professional practice, context, and knowledge in an integrated learning system" (Daley, 2000, p. 34). This systems perspective aimed to highlight and embrace complexity in professional practice and pair it with similarly complex learning experiences situated in practice such that learning consisted of working actual practice problems to "promote the ability to work in the uncertain, confusing, and dynamic world of professional practice for the betterment of clients" (Daley & Mott, 2000, p. 81).

Awareness of practice as the source and setting of professional learning was augmented by appreciation for learning processes as dependent on context, particularly through social elements like interaction with others (Webster-Wright, 2009). The effects of such social influences within a given setting were notably missing from most research on continuing professional education (Jeris, 2010). However, there were some voices on these issues; in Wenger's (1998) work on communities of practice, Dirkx et al. (2004) noticed collaborative and relational dynamics and how these shaped an individual professional's experiences of learning.

As context was incorporated to discourse of continuing professional education, there emerged classification of learning opportunities, strategies, and experiences into those which were situated in – "informal" (Webster-Wright, 2009) or "experiential" (Coady, 2015) learning conducted during the course of daily work – and those which were separate from – "formal" programs provided for the purposes of professional development (Coady, 2015; Webster-Wright, 2009) – practice.

Eraut's learning professionals. Eraut was read as cognizant of an arbitrary dichotomy of formal and informal professional learning. He studied the role of continuing professional education in the ongoing development of professionals in many fields and over the course of many years. He described professional development simply as when "people recognized a need for some additional knowledge or skill to improve the quality of their work or expand its range" by drawing on self-direction and available learning opportunities (Eraut, 2012, p. 22). He contrasted this straightforward concept with the state of knowledge of professional learning:

> We know very little about what is learned during the period of initial qualification besides the content of formal examinations. Still less is known about subsequent learning, how and why professionals learn to apply, disregard or modify their initial training immediately after qualification; and to what extent continuing on-the-job or even off-the-job learning contributes to their professional maturation, updating, promotion or reorientation. (Eraut, 1994, p. 40)

Eraut argued that continuing professional education had been commodified and was offered under "a market model in which providers advertise conferences, courses, and workshops" (Eraut, 2012, pp. 37-38); scope and impact of such learning were limited, and linkage to actual practice was weak as little attention was paid to the knowledge potential stemming from participants' rich work experiences (Eraut, 1994). While similarly divorced from practice, continuing professional education in Eraut's (2012) framing, having lost the sheen of an honorable aim to further professional development, was a step beyond assessment of professional education for the purposes of regulation (Coady, 2016; Webster-Wright, 2009; Wilson, 2000).

With the personal nature of professionals' knowledge front of mind, Eraut made suggestions for authentic education aimed at promoting professionals' development. In a manner quite similar to Cervero's critical viewpoint of continuing professional education, Eraut argued "that knowledge needs to be brought under critical control by developing greater awareness of how it is used and re-examining taken-for-granted assumptions" (Eraut, 1994, p. 106), and this should be the focus of professional learning objectives and activities. To this end, professional learning had to consider the setting, time, resources, people, and capacity to learn (Eraut, 1994). Such an approach would be situated in the professional's lived experience and each adult learner's particular circumstance would be respected. This hinted at the melding of dual identities – professional and learner.

> As people become more professional about the way they approach, manage and pursue their own learning, they will be better able to assess the way learning is supported... Hence the need to be "professional learners" in order to become more effective "learning professionals". (Eraut, 1994, p. 14)

This statement demonstrated the reorientation of learning related to practice – the informal or experiential – as the primary, central source of professionals' learning that could then be supported by formal learning activities. Self-direction was reinforced as an integral aspect of oversight over all types of experiences generating learning in his viewpoint.

Self-direction. As a theme in the continuing professional education literature, self-direction was highlighted as a key component of Nowlen's competence model of continuing professional education (Mott, 2000), as a motivating trait that focuses attention and energizes behaviors. Bluestone et al. (2013) in their review of effect in-service trainings for health professionals found that self-directed approaches could be effective, though needed to be highly interactive. Cervero and Daley (2016) identified a greater presence of self-directed options in more recent studies of continuing professional education. Interestingly, while self-direction was acknowledged to have potential interplay with continuing professional education by means of implications for processes and outcomes, Cervero and Daley raised the question as to "whether individual professionals will engage actively and assume responsibility for this level of independence in managing their own learning" (Cervero & Daley, 2016, p. 16), intimating potential confounding of the efficacy of learning due to individual factors.

Meaning-making. Mentions of self-direction in the continuing professional education literature acted as entrée to exploration of professionals' internal experiences of learning. Such exploration generated arguments in favor of understanding professional learning as a constructivist, meaning-making process. "Learners engaged in meaningful learning craft their own idiosyncratic significance for new information, making the learning both new and more relevant through its application to a specific context" (Mott, 2000, p. 27). That information was morphed and new meaning created by the practitioner's application of learning to practice was substantiated by Dirkx et al. (2004), who added the notion of reciprocal impact – practice changed learning and learning changed practice: "practitioners transform these generalities into useful, practical knowledge, but in struggling with their application, their experience of practice is also transformed" (p. 39). They described a process in which information introduced through education mingled with the professional's past experiences and understandings as information was applied to adjust work behaviors, all of which occurred within context of a social sort (Dirkx et al., 2004, p. 40). Drawing on several theorists, Coady (2015) summarized the phenomenon as "professionals made knowledge meaningful through constructivist learning – by establishing connections between the knowledge learned (through CPE), previous experiences, and the context in which they found themselves, as well as how they perceived that context" (p.68). Learning in this manner was noted to be highly individualized and, also by virtue of enactment through practice, authentic (Coady 2015; Webster-Wright, 2009).

Conclusion

Taken together, the studies reviewed above demonstrated the challenge that innovations in genomic technologies presented to genetic counseling practice. Several studies (Bernhardt et al., 2014; Bower et al., 2002; Groepper et al., 2015; Machini et al., 2014; Tomlinson et al., 2016) highlighted the uncertainty and discomfort genetic counselors experienced in response to this situation, in which they perceived themselves as inadequately trained. To alleviate these concerns, repeated calls for continued professional learning and development on genomic technologies and the impact on practice were identified in the literature (Bernhardt et al., 2014; Machini et al., 2014; O'Daniel, 2010; Profato et al., 2014; Weitzel et al., 2011; Wicklund & Trepanier, 2014). However, these discussions were taking place against a backdrop of inadequate understanding of genetic counselors' professional development in general (Zahm, 2009). Collectively, these revealed a dearth of understanding of the professional learning and development of genetic counselors overall, and particularly with respect to the professional learning and development in response to innovations and the uncertainty such innovations may introduce (Han et al., 2017).

Lack of understanding of professional learning was not, however, limited to the genetic counseling literature. Experiential learning, with special attention to reflection-in-action, provided a model for a practitioner's response to and interaction with a changing and complex work environment (Fenwick, 2000; Nicolaides & Yorks, 2008; Schon, 1983). Though theories of reflection as a means for learning were well developed, empirical evidence of reflection for professional development in healthcare professions was minimal or muddled (Gustafsson & Fagerberg, 2004; Mann et al., 2009). In contrast to individualized accounts of reflection, communities of practice offered insight into social learning (Brown & Duguid, 1991; Lave & Wenger, 1991; Wenger, 1998, 2000, 2011), though in the healthcare literature, communities of practice were less often naturally occurring collectives and more likely to be framed as specialized learning interventions, a shift which potentially deprived communities of practice of their inherent energy and efficacy (Ranmuthugala et al., 2011). Neither reflection nor communities of practice offered clear and complete frameworks of how professionals learn. Even literature from adult education and healthcare on continuing professional education demonstrated incomplete understanding and insights under construction, in development (Cervero, 2000; Cervero & Gaines, 2014; Mott, 2000; Robertson et al., 2003; Schostak et al., 2010; Webster-Wright, 2009). Views of professional learning as transactional updates to knowledge or skills (Cervero, 1988; Mott, 2000) were counterpoised with descriptions of professional learning situated in the context of practice, constructing personal meaning and knowledge through application to work (Dirkx et al., 2004; Eraut, 1994; Webster-Wright, 2009). Interestingly, Webster-Wright (2009) highlighted that "many studies… assume a dualist ontology that implies professionals can be studied in a meaningful way separate from their professional practice" (p. 713), and research in this area tends to focus on competence rather than the learning processes and activities that produce such competence (Webster-Wright, 2009). When the object of study was the complex, dynamic learning that takes place among professionals to produce a shift in practice within ambiguous circumstances, research efforts should not "divide and conquer", separating the phenomenon into separate but equal parts for analysis.

> Research is required that views the learner, context, and learning as inextricably interrelated rather than acknowledged as related, yet studied separately. The "experience" of learning in everyday practice is rarely studied in a way that maintains the integration of all these aspects. There is a need for more research beyond the "development of professionals" that investigates the "experience of [professional learning] as constructed and embedded within authentic professional practice". (Webster-Wright, 2009, pp. 712-713)

Webster-Wright (2009) called for a new kind of research that allowed integral components of learning to remain in equilibrium throughout the research process, thereby aiming for a better approximation of learning in practice as experienced by practitioners. The research included in this review provided evidence of the need for such studies of genetic counselors as their learning and practice evolve in conjunction with genomic technologies on individual and collective levels; the present study sought to Webster-Wright's call.

Conceptual Framework

The conceptual framework for this study was centered on the concept of genetic counselors' professional learning within the practice context. Literature on professional development in genetic counseling, genomic technologies and attendant uncertainties, ambiguity tolerance, learning from experience, communities of practice, and continuing professional education were explored and interconnected to form a networked investigation of the professional learning of genetic counselors. Individual learning, as well as specific strategies and resources, and the role of colleagues were foci of this study and were further clarified by attending to the following potential mediating factors: ambiguity tolerance, specialization within genetic counseling, and years of experience. This study explored possible correlations among themes on learning, strategies, and preferences that had not been demonstrated in the professional literature of the field.

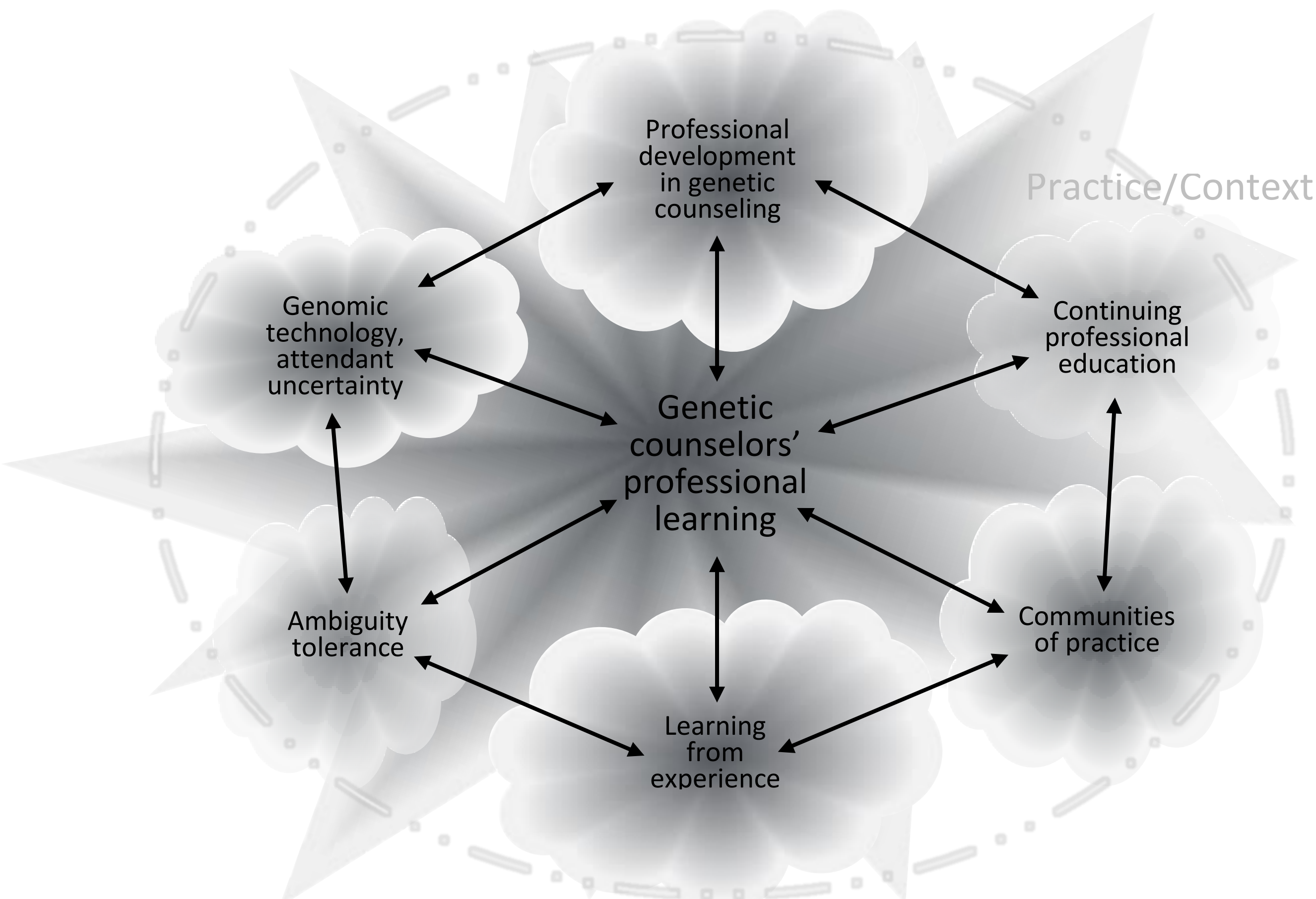


Diagram 1. Conceptual framework.

Chapter III

METHODOLOGY

As the professional learning of genetic counselors had not been thoroughly researched, this study employed a tripartite design to draw on complementary strengths of multiple data collection and analysis methods, similar to the philosophy of mixed methods research. Assuming a mixed methods orientation "give[s] primacy to the research question and value[s] both objective and subjective knowledge" (Silver & Lewins, 2014, p. 31). This study design complemented the open-ended, subjective, generative qualities of qualitative data with retrospective, objective, concretized quantitative data. Multiple data sources allowed for triangulation as "an attempt to secure an in-depth understanding of the phenomenon in question" (Denzin, 2012, p. 82). Each phase of the research process informed development of subsequent phases and data gathered by various collection methods generated a more comprehensive understanding than each method alone (Creswell, 2014).

Qualitative data collection consisted of gathering critical incident questionnaires then conducting semi-structured interviews. Two mediums – one written and one verbal – aimed to elicit different opinions and perspectives. Quantitative data collection acquired demographic information, ambiguity tolerance scores, and an online database of continuing education unit (CEU) credits, into which entries of professional learning activities were submitted for the purposes of maintaining certification status. Qualitative analyses generated themes whereas quantitative analyses characterized the study population, assessed whether themes varied by demographics or AT score, and analyzed whether themes from the CIQ and interview samples were reflected more broadly across the profession and through formalized tracking mechanisms.

To elucidate the complementarity of datasets, Table 2 provides a matrix of how methods addressed this study's research questions and sub-questions.

Table 2

Methods' Matrix

Research Questions	Demo-graphics	Critical incident	Interviews	CEU database	Ambiguity tolerance
How do genetic counselors leverage learning to incorporate scientific innovations into practice?	X	X	X	X	X
What learning strategies and resources do genetic counselors utilize for professional learning?		X	X	X	
What roles do specialization and years of experience play in selection of learning strategies and resources?	X	X	X		
What roles does tolerance for ambiguity play in selection of learning strategies and resources?		X			X
How does interaction with colleagues influence the professional learning of genetic counselors?		X	X		

Datasets were independently analyzed and subsequently compared to each other, as depicted in Diagram 2. CIQs were acquired and analyzed first; this analysis informed the interview protocol. The CIQ and interviews together revealed qualitative themes, the CEU database offered quantitative data, and all together informed the comprehensive analysis.

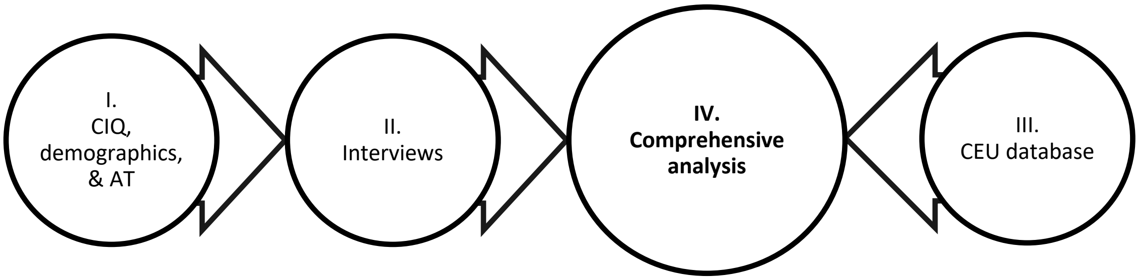


Diagram 2. Sequence of data collection and analysis.

Eligibility and Recruitment Criteria

All genetic counselors practicing in the United States and Canada were eligible to participate in this study; students in genetic counseling training programs were not eligible. Genetic counselors were recruited through the National Society of Genetic Counselors list of members to complete concurrently the critical incident questionnaire, demographic inventory, and ambiguity tolerance assessment. Interviewees were recruited from respondents who completed the CIQ and voluntarily expressed interest in a follow-up interview by submitting their email address with the CIQ. Attempts were made to ensure genetic counselors from the most common specialties (particularly prenatal/reproductive genetics, cancer genetics, general/pediatric genetics, laboratory, and research) were represented among participants for the CIQ and interviews. Similarly, efforts were made to include practitioners with various years of experience and from various geographic locations. Table 3 illustrates proportions of genetic counselors working in the five most common specialties and with increasing years of experience; these figures were drawn from responses to the National Society of Genetic Counselors 2014 Professional Status Survey and likely underestimated the number of eligible participants for this study given the response rate for the 2014 PSS (44%) (NSGC, 2014b) and the rapidly expanding number of genetic counselors. However, these crosstabs of years of experience and specialty informed recruitment of study participants, aiming toward a proportionate and representative study sample.

Table 3

Potential Participant Pools by Specialty and Years of Experience

Years of experience > **Specialty v**	**1-4**	**5-9**	**10-14**	**15+**	**TOTAL**
Prenatal	147	96	44	23	**310**
Cancer	157	71	25	13	**266**
Pediatrics	66	24	7	15	**112**
Laboratory	52	11	6	2	**71**
Research	41	14	4	3	**62**
TOTAL	**463**	**216**	**86**	**56**	**821**

The recruitment goals for this study were a minimum of sixty critical incident questionnaires and twenty interviews. This study balanced maximum diversity in terms of specialty and years of experience with representativeness of the profession as a whole when recruiting participants.

Data Collection and Analysis

Multiple sources of data were collected to generate various and complementary insights into the topic of professional learning of genetic counselors. Data collection proceeded in three-phases: (1) online demographic inventory, critical incident questionnaires, and optional ambiguity tolerance assessment, (2) semi-structured, audio-recorded interviews, and (3) a database of continuing education unit credits. Details of data collection and analysis of each are provided below.

Considering the potential amount, variety, and complexity of data in this study, computer-assisted qualitative data analysis software (CAQDAS) was employed to facilitate analysis following coding. "CAQDAS, unlike the human mind, can maintain and permit you to organize evolving and potentially complex coding systems into such formats as hierarchies and networks for 'at a glance' user reference" (Saldana, 2013, p. 31). MAXQDA software was chosen for this purpose as it offered functionality in combining qualitative and quantitative data of mixed methods research, particularly by providing the option of "*joint displays* that bring together qualitative and quantitative results in one integrated table" (Silver & Lewins, 2014, p. 69). CAQDAS facilitated interrogation of "where particular codes co-occur, overlap, appear in a sequence, or lie in proximity to each other. These search functions can perform such human actions as infer, make connections, identify patterns and relationships, interpret, and build theory with the data (Lewins & Silver, 2007)" (Saldana, 2013, p. 32). For that analogous reason of ease of use, Microsoft Excel and IBM SPSS Statistics 24 were utilized as platforms for quantitative data analyses.

Demographic Inventory

Demographic information was requested from all study participants as the first component of the online critical incident questionnaire (as seen in Appendix A). In addition to ascertaining specialty and years of experience for analyses as potential factors influencing selection of learning strategies and resources, the demographic inventory was used to determine interest in participating in a follow-up interview and track recruitment of interviewees to balance participation of various demographic groups in line with the structure of the profession. Knowing participants' specialties also enabled analyses of the potential influence of variations, scientific innovations and technologies encountered, and professional learning strategies enacted in each specialty setting. Obtaining information on years of experience enabled comparison and contrast of opinions on professional learning across cohorts that were expected to experience similar social and technological trends. Additional demographic information included gender, age, geographic region of practice, and type and kind of formal training or education beyond a master's degree from a genetic counseling training program, any or all of which could influence a genetic counselor's professional learning, preferred strategies and resources, and perspectives as reported in the critical incident questionnaires or during interviews. The demographic inventory was designed to support granular analysis of gradations in the data by producing distinct categories for comparison – categories which were consistent with those frequently utilized in the professional literature of genetic counseling (NSGC, 2014b).

Critical Incident Questionnaires

A critical incident questionnaire (CIQ) was designed to gather detailed experiences of genetic counselors' professional learning in response to scientific innovations. CIQs elicited opinions and perspectives on behaviors via targeted reflective questions "in such a way as to facilitate their potential usefulness in solving practical problems and developing broad psychological principles" (Flanagan, 1954, p. 327). As this study's research questions situated innovation as a practical problem requiring solution, the CIQ was deemed a suitable instrument for ascertaining professional learning beliefs and behaviors (as evidenced by perceived and preferred strategies and resources) as problem-solving responses to innovation. The tool itself was quite flexible, lending itself to use for a variety of research purposes (Flanagan, 1954). This method was also chosen for "its capacity to explore differences or turning points; and its utility as both a foundational/exploratory tool in the early stages of research and its role in building theories or models" (Butterfield, Borgen, Amundson, & Maglio, 2005, p. 480). In keeping with its purported functionality, the CIQ dutifully generated a pool of examples in which genetic counselors experienced innovation as an impetus to shift practice (examples which arguably qualify as the "turning points" theoretically targeted by critical incident questionnaires) as well as accounts of approaches to professional learning utilized in service to applying these innovations to practice. The CIQ as it was distributed is included in Appendix A.

As a CIQ can be distributed to few or many potential respondents with the same amount of initial effort, an email invitation to complete a CIQ online was sent to the full membership of the National Society of Genetic Counselors (a population of over 3000 members), most of whom were practicing genetic counselors with the potential to have pertinent experiences of incorporating scientific innovations into practice. The rationale for recruiting via the NSGC listserv was that most members of the listserv were likely to meet eligibility criteria and the considerable number of potential participants was expected to offset the expected low response rate.

The email invitation included a link to a Qualtrics survey; the landing page for the link included an informed consent statement which can be found in Appendix P. At the end of the informed consent statement, participants were prompted to click "Next" to begin the CIQ; clicking "Next" and entering responses was taken as evidence of informed consent and agreement to participate in the study. To this end, waiver of documentation of informed consent for CIQs was requested from and granted by the Teachers College Institutional Review Board, as the CIQ was not expected to pose more than minimal risk to participants and written documentation of consent would have constituted the only required information which could identify participants and create a risk of breach of confidentiality.

CIQ response rates. The email invitation to complete the CIQ was sent to 3200 recipients via the National Society of Genetic Counselors' listserv on October 14, 2015. A second, reminder email was sent on November 2, 2015. Of the 3200 emails, 77 (2.4%) were returned with bounce notifications and 873 (28% of the 3123 emails delivered) were opened. Qualtrics recorded 343 unique responses, representing 39% of opened emails and 11% of delivered emails. Out of the 343 responses, 114 included a complete CIQ, defined as coherent, purposeful responses to all four questions of the questionnaire; a total of 114 complete CIQs represented 33% of responses in Qualtrics and 3.65% of delivered emails. Only complete CIQs were included in the analysis.

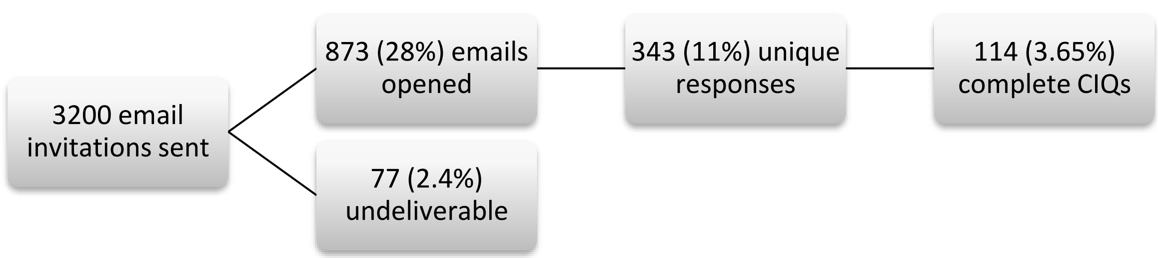


Diagram 3. Response rates for critical incident questionnaires.

All 343 responses submitted online were downloaded from the Qualtrics site as an Excel database and stored as a password-protected file on the researcher's personal computer. All 343 were given a unique response identification number in accordance with the order in which they were submitted in Qualtrics. Each CIQ was then reviewed for completeness and anonymity. Incomplete CIQs (those missing intentional text in response to at least one question) were deleted from the database, leaving the full set of completed

CIQs with non-continuous response identification numbers. Each completed CIQs was formatted into a pdf or word file type and uploaded into the MAXQDA data analysis program.

CIQ participant profile. Descriptive statistics were performed on each item of the demographic inventory, including frequency, corresponding percentage, average, and range as appropriate, for those respondents completing the critical incident questionnaire, a full summary of which is included in Appendix B. The sample of genetic counselors who submitted critical incident questionnaires assumed the following profile (also found in Appendix B): 96.5% were women, 95.6% had a master's degree in genetic counseling (or equivalent degree), and 95.6% had achieved certification. The average age of participants was 36.6 years (range: 23-62 years) and the average number of years working as a genetic counselor was 9.7 years (range: less than 1-37 years). With respect to specialty, approximately 26% of participants specialized in cancer genetic counseling, 22% in a generalized "other" category (including those working in industry or both clinical and non-clinical specialties), 19% in prenatal/reproductive genetic counseling, 9% in pediatric/general genetic counseling, 9% in multiple clinical specialties, 9% in laboratory genetic counseling, and 5% in research. Participants had worked in their respective primary specialty an average of 6.7 years (range: 0.3-35 years). For years of experience and specialty, the collective profile of participants submitting critical incident questionnaire somewhat mirrored the profile of the profession of genetic counseling as reported in the most recent professional status survey (NSGC, 2016) – the most common specialty being cancer and with the majority working for fewer than 10 years.

CIQ qualitative analysis. Prior to analysis, a preliminary coding scheme generated from review of relevant literature and the researcher's previous experiences was revisited to reacquaint the researcher with potential codes. A draft of the initial coding scheme can be found in Appendix S.

All CIQs were read through in their entirety to familiarize the researcher with the dataset; notes were made during the initial read-through to document potential codes and emergent questions. Following the first reading, a second reading was initiated for the purposes of open coding, a process in which each unit of text conveying a discrete, meaningful idea was coded with inductively derived codes as dictated by the data. The developing coding scheme was consistently reviewed for specificity of each code's application, redundancy between codes, and determination of the need for new codes. The coding scheme was applied holistically to each critical incident questionnaire; no stipulations were made in terms of restricting certain codes to responses to specific questions. Open coding was followed by axial coding; all text segments to which a code was ascribed were reviewed to ensure coherence of meaning and consistency of the use of the code. If a text segment was found to be discrepant with the code's framing and operation, the code was removed from the text segment and the text segment was assessed for reassignment to a more relevant code as appropriate. An excerpt from a coded critical incident questionnaire is included in Appendix D.

Several colleagues in adult education and one genetic counselor were asked to review the coding scheme, use the coding scheme to code ten CIQs for comparison and contrast with the researcher's coding calls, and share thoughts and questions that arose when doing so. In particular, the genetic counselor questioned and clarified codes related to triggers of learning and outcomes, whereas adult education colleagues were drawn to analysis of codes related to learning strategies. Suggestions and clarifications from colleagues' comments and questions informed adjustment of the coding scheme.

Once coding was completed, the coding scheme as a whole was reviewed for coherence and redundancy: similar or related subcodes were gathered under an overarching parent code created for this purpose; parent codes were arranged in logical order. The final coding scheme – including number of text segments coded with each code, number of documents (with one document representing one respondent) including each code, and percent of documents including each code – is included in Appendix C.

CIQ coding scheme. The final CIQ coding scheme consisted of five parent codes: Trigger (Innovation), Impact, Insight, Learning, and Outcome. These parent codes aligned with the structure of the CIQ: question one prompted identification of an innovation impacting practice; question two invited descriptions of learning enacted to promote adjustment to the innovation; question three requested specification of actions taken; and question four inquired about consequent outcomes. The Insight parent code captured statements regarding participants' reflections and realizations regarding their learning.

CIQ quantitative analyses. Quantitative analyses of coded data included frequency counts and calculation of proportion of respondents with statements falling into each code as evidenced by text segments coded with that code present in the respondent's CIQ. Main thematic categories abstracted from this study's research questions regarding learning strategies were subjected to chi square goodness-of-fit tests to assess for variation by specialty, years of experience, and AT score in accordance with the study's goals and to test the researcher's assumptions. Tables of findings from the chi square tests are located in Appendix E.

Ambiguity Tolerance Assessment

As accounts of ambiguity and uncertainty in response to innovation were present in the genetic counseling and healthcare literature, an assessment of ambiguity tolerance (AT) as a potential modifier of learning preferences was included as an optional addendum to the critical incident questionnaire. AT was assessed using the Multiple Stimulus Types Ambiguity Tolerance scale II (MSTAT-II). Permission to use the MSTAT-II for this study was obtained on June 2, 2015 via response to an email request to the developer of this measure, David McLain.

This study implemented the MSTAT-II via a separate page attached to the Qualtrics survey for the critical incident questionnaires (see Appendix A). At the end of the CIQ, participants viewed an invitation to complete an optional assessment of response to ambiguity. To complete the assessment, participants were required to click "Next". Declining to complete the AT assessment did not disqualify a complete CIQ from analysis. The MSTAT-II includes 13 items which assess an individual's response to statements reflecting various levels of ambiguity; participants were prompted to respond to each statement with a number on a Likert-like scale of 1 to 7, with 1 corresponds to "strongly disagree" and 7 corresponds with "strongly agree". Items 1 through 6, 9, 11, and 12 were reverse-scored, then responses to all thirteen items were summed to a score indicating the individual's ambiguity tolerance. The MSTAT-II AT assessment has a range of scores from 13 to 91, as there are 13 items each with a possible score of 1 to 7. Lower scores indicate lower tolerance for ambiguity.

AT response rate. Of the 343 unique responses to the critical incident questionnaire, 135 (4.32% response rate) completed the AT assessment. Scores for each of the thirteen items was recorded in Qualtrics and transferred to a separate database for analysis. Scoring and formatting were conducted in Microsoft Excel then transferred – along with age, specialty, and years of experience demographics – to IBM SPSS 24 for analysis. Descriptive statistics, analysis of variance, and linear regression modeling were conducted in SPSS on 135 complete AT assessments.

AT participant profile. Demographic information for respondents completing an AT assessment were analyzed with descriptive statistics in the same manner as all respondents completing a CIQ. The sample of genetic counselors who submitted AT assessments had an average age of 36 years (range: 23-62 years) and an average number of years working as a genetic counselor of 9.4 years (range: less than 1-37 years) (see Appendix F). In terms of specialty, approximately 24% of participants specialized in cancer genetic counseling, 20% in prenatal/reproductive genetic counseling, 17% in a generalized "other" category (including those working in industry and multiple specialties), 14% in multiple clinical specialties, 11% in laboratory genetic counseling, 10% in pediatric/general genetic counseling, 4% in research, and one not reporting specialty. This profile of those submitting AT assessments tracked with those submitting CIQs (Table 4), and with the profile of the profession as a whole.

Table 4

Comparison of Participant Demographics Across Datasets

	CIQ	AT	Interviews
Total participants	114	135	21
Female	110 (96.5%)	132 (97.8%)	20 (95.2%)
Master's degree in genetic counseling	109 (95.6%)	130 (96.3%)	19 (90.5%)
Certified	109 (95.6%)	129 (95.6%)	20 (95.2%)
Average age	36.6 (range 23-62)	36 (range 23-62)	36.4 (range 24-62)
Average years working as GC	9.7 (range 1-37)	9.4 (1-37)	9.4 (range 1-35)
Specialty			
Cancer	30 (26.3%)	32 (23.7%)	5 (23.8%)
Prenatal/reproductive	22 (19.3%)	27 (20.0%)	2 (9.5%)
Pediatric/general	10 (8.8%)	13 (9.6%)	4 (19.0%)
Multiple clinical	10 (8.8%)	19 (14.1%)	-
Lab	10 (8.8%)	15 (11.1%)	3 (14.3%)
Research	6 (5.3%)	5 (3.7%)	3 (14.3%)
Other	25 (21.9%)	23 (17.0%)	4 (19.0%)
None	1 (0.9%)	1 (0.7%)	-

AT quantitative analyses. Descriptive statistics were calculated for all 135 AT scores and by categories of specialty, years of experience in genetic counseling, and age to depict overviews of AT scores for various cross-sections of the study population. Analysis of variation in AT score by specialty was conducted by regressing AT score by specialty as a categorical variable using contrast codes (linear regression) and one-way ANOVA (analysis of variance) comparison of AT scores in clinical (prenatal, cancer, pediatric/general, and multiple clinical) versus non-clinical (laboratory, research, and other) specialties. Analysis of variation in AT score by years of experience in genetic counseling was assessed by regressing AT score by years of experience as a continuous variable. And for comparison to influence of years of experience, variation in AT score was regressed by age as a continuous variable. Full results of these analyses are included in Appendix F.

Interviews

Initial analysis of CIQs revealed themes meriting additional clarification; these themes consisted of the following: the extent and nature of awareness of engaging in professional learning, depth and detail of preferences for particular learning strategies, motivations surrounding involvement of colleagues in learning experiences, and philosophies of professional learning as embedded in advice given and received. CIQ responses, while instrumental in framing themes of professional learning, were deemed too concise and circumscribed to allow for thorough analysis of the aforementioned areas; therefore, this study proceeded to interviews to complement discrete CIQ data with detailed, rich accounts of professional learning as acquired through interviews.

Interviews followed a semi-structured protocol which consisted of 10 questions of genetic counselors' thoughts on various aspects of professional learning; the final interview protocol is included in Appendix G. Interviews aimed to complement written CIQs by nurturing a dialogue between a genetic counselor and the researcher, also a genetic counselor. The interview protocol, initially drafted from themes arising in the literature, was piloted with two experienced genetic counselors in the spring of 2015 and minor adjustments were made to wording and question order as a result of their feedback. The interview protocol was subsequently edited after initial analysis of the CIQs in coordination with colleagues in adult education in the fall of 2015, which yielded themes in need of additional data and analysis.

Interviews were conducted by phone or in-person and audio-recorded using a plug-in digital recording device and a telephone application called TapeACall; two methods of recording were used for redundancy. All interview recordings were transcribed by the researcher using Express Scribe Transcription software and Microsoft word. Transcription by the researcher allowed for deep immersion in the data. Transcripts were reviewed for identifiers, which were removed prior to saving, and assigned a pseudonym (see Table 23 in Appendix H). Transcripts were then saved in password-protected files on the researcher's personal computer, reformatted into the file type (pdf) necessary for upload into the MAXQDA data analysis program, and imported into the program for analysis.

All submitted CIQ responses were reviewed for respondents who expressed interest in a follow-up interview by providing an email address; specialty and years of experience for each were examined to craft a categorized list of potential interviewees. Potential interviewees were sent an email with a description of the study and steps to scheduling a time to speak: completing and returning an attached consent form (included in Appendix Q) and forwarding convenient appointment times was taken as indication of willingness to be interviewed, though signed consent form constituted documentation of consent.

Interview response rate. Review of the CIQs revealed 81 respondents who volunteered for a follow-up interview; 44 of these had completed the critical incident questionnaire (defined as intentional responses to all four questions of the CIQ) and 37 had not. Email invitations were sent in several batches, first in March and again in October of 2016; each batch aimed to enhance diversity of perspectives with respect to years of experience and specialty. Respondents with a completed CIQ were prioritized within their respective specialty and years of experience categories as potential interviewees and were among the first batch of email invitations to interview. Categorization by years of experience and specialty showed a reasonable distribution. A total of 56 potential interviewees were emailed to accrue 21 interviews (37.5% response rate). All 21 Interviews followed the final interview protocol; the resulting conversations lasted an average of 32 minutes (range 17-54 minutes). Interviews were conducted March through December of 2016.

Table 5

Interviewee Recruitment Pools by Specialty and Years of Experience

Years of experience > **Specialty ˅**	**1-4**	**5-9**	**10-14**	**15+**	**TOTAL**
Prenatal	5/5 (1)	1/1 (0)	1/1 (1)	0	**7/7 (2)**
Cancer	7/9 (2)	2/3 (1)	3/3 (1)	2/3 (1)	**14/18 (5)**
Pediatrics	3/4 (2)	2/2 (2)	0	0	**5/6 (4)**
Laboratory	1/1 (0)	1/1 (1)	2/2 (1)	2/3 (1)	**6/7 (3)**
Research	1/1 (0)	3/3 (3)	0	1/1 (0)	**5/5 (3)**
Other	5/10 (1)	4/6 (1)	4/7 (1)	6/15 (1)	**19/38 (4)**
TOTAL	**22/30 (6)**	**13/16 (8)**	**10/13 (4)**	**11/22 (3)**	**56/81 (21)**

* Proportions are framed as “number invited”/ “number expressing interest”. Numbers in parentheses indicate actual interviewees in a given category.

Interview participant profile. By design, the group of genetic counselors completing interviews represented a subset of those completing CIQs, with the exception of one interviewee who had not completed a CIQ but was included as she worked in a specialty that was underrepresented. Interviewees had the following demographics (also found in Appendix H): 95.2% were women, 90.5% had a master’s degree in genetic counseling (or equivalent degree), and 95.2% had achieved certification. The average age of interviewees was 36.4 years (range: 24-62 years) and the average number of years working as a genetic counselor was 9.4 years (range: less than 1-35 years). In terms of specialty, approximately 24% of participants specialized in cancer genetic counseling, 19% in a generalized “other” category (including those working in industry and multiple specialties), 19% in pediatric/general genetic counseling, 14% in laboratory genetic counseling, 14% in research, and 10% in prenatal/reproductive genetic counseling. Participants had worked in their respective primary specialty an average of eight years (range: 0.3-35 years). Table 5 above displays distribution of specialty and years of experience of all interviewees. With respect to years of experience and specialty, the collective profile of interviewees somewhat aligned with the sample of respondents submitting CIQs and the profile of the profession of genetic counseling as reported in the most recent professional status survey (NSGC, 2016), the exceptions being specialty and years of experience categories were more evenly distributed than in the profession as a whole and there was a small number of prenatal genetic counselors participating in interviews.

Interview qualitative analysis. All interview transcripts were read through in their entirety to familiarize the researcher with the dataset; notes were made during the initial read-through to document potential codes and emergent questions. These notes were compared with the preliminary coding scheme (Appendix S) and CIQ coding scheme (Appendix C) to assess whether aspects of these coding schemes could be applied to the interview transcripts. Of note, the CIQ coding scheme was experimentally applied when coding two interview transcripts. This caused sufficient difficulty and incongruence to prompt abandonment of that approach and instead, a second, separate inductive coding scheme was developed specifically during analysis of the interviews. As such, a second reading of all interview transcripts was initiated for open coding. Similar to coding the CIQs, each unit of text conveying a discrete, meaningful idea was coded with inductively derived codes as required by the data. The developing coding scheme was consistently reviewed for code specificity, redundancy, and addition of new codes. Axial coding followed, ensuring all text segments coded with a given code related to a consistent theme; discrepant statements were removed and recoded as needed. An excerpt from a coded interview transcript is included in Appendix M. The coding scheme and researcher's coding calls were again subjected to comparison and contrast with two colleagues in adult education and one genetic counselor; conversation with adult education colleagues targeted codes on social components of learning, whereas the genetic counselor was most interested in debating codes on broad themes. Several codes were differentiated or adjusted in response to these interactions.

After axial coding and adjustment following discussion with colleagues, the coding scheme was reviewed for clarity, coherence, and redundancy. Relevant subcodes were gathered under overarching parent codes. The final coding scheme included number of text segments within each code, number of documents (with one document representing one interviewee) including each code, and percentage of interviewees making statements related to each code (Appendix I).

Differences in preferences regarding learning strategies as mediated by specialty, years of experience, or ambiguity tolerance were explored. Variation of strategies as identified and described by interviewees was examined as follows: across specialties – prenatal/reproductive genetics, cancer genetics, pediatric/general genetics, laboratory, research, and other (including participants working in multiple specialties, hybrid roles, or those not otherwise listed) (Appendix J); among categories of years of experience – 0-4 years, 5-9 years, 10-14 years, and 15 + years (Appendix K); and among categories of ambiguity tolerance scores – less than 56, 56-61, 62-67, more than 67 (Appendix L). Proportion of interviewees in each group were compared for all themes to identify features of professional learning on which specialty, years' experience, or ambiguity tolerance might have an influence.

Interview coding scheme. The final interview coding scheme was constructed on six parent codes: Opportunities for learning, Learning process, Evidence of learning, Advice, Messaging, and Broad themes. These parent codes loosely tracked the interview protocol in that questions prompted interviewees to identify moments in which they were aware they were learning, describe the form and shape that learning assumed, recognize when they had learned what they set out to learn, offer advice to other genetic counselors, and analyze any messaging around professional learning. The final interview coding scheme is included in Appendix I.

Database of Continuing Education Units

Considering both the CIQ and interview datasets were constituted by qualitative data, a quantitative dataset was sought to juxtapose subjective perceptions with objective data related to professional learning of genetic counselors. The American Board of Genetic Counseling (ABGC) is the organization responsible for overseeing and coordinating certification for practicing genetic counselors in the United States of America. Since 2012, ABGC has tracked continuing education units (CEUs) via an online database. Genetic counselors enter information about their continuing education activities for the purposes of recertification on a ten- or five-year cycle (the cycle length was shortened from ten to five years for the cohort of diplomates certified in 2010 and all subsequent cohorts). Entries can be made to the database at any time, not strictly at the time of recertification. Entries require free-text title of the continuing education activity, start and end dates, date of entry into database, credit hours earned, course type, and course category. There are three categories of credit for continuing education units: category 1 – activities specific to genetics and genetic counseling; category 2 – activities in related disciplines which have received continuing education certification by other professional societies; and professional activity credits – activities such as supervision, outreach, publishing, teaching, or volunteering.

In this study, continuing education units were viewed as a proxy for professional learning activities – specifically those recognized, approved, and sanctioned by the profession's credentialing organization – that could be quantified and analyzed to reveal preferences of learning strategies across the profession as a whole. Framing the relationship between CEUs and professional learning was acknowledged to influence analysis given the compulsory slant of professional learning in relation to certification.

In the summer of 2016, the researcher contacted ABGC to request access to all deidentified entries made to the online CEU tracking system. A data-sharing agreement was drafted and endorsed by the researcher and ABGC (see Appendix R). The deidentified database was downloaded from the ABGC website and transferred to the researcher as an excel file for coding and analysis.

Database characteristics. The database of continuing education units was obtained from the ABGC on June 20, 2016. New sheets were added to the database to separate categories of credits, one sheet each for category 1 credit entries, category 2 credit entries, and professional activity credit entries. An initial round of open coding was followed by a second, "cleaning" round of coding to crosscheck initial coding, together producing 43131 unique entries summing to 43426.48 total credits, which underwent quantitative analysis.

Database qualitative coding. All entries in the continuing education database were coded with simple qualitative codes. The first round of open coding consisted of reviewing each entry and transforming the free-text entries from the online tracking database into standardized codes which would be amenable to quantitative analysis. Seven aspects of each entry were assessed: year in which activity occurred, sponsoring organization, type of activity (such as conference, workshop, symposium, course, or unspecified), topical area (or focus), whether the activity was conducted online or in-person, if any discrepancy or potential error was suspected or identified, and a notes section to document questions and comments. After all entries were coded in this way when originally sorted by activity start date, the database was sorted by organization and each entry was assessed for accurate coding when grouped in this alternate way. In this permutation, a second attempt was made to code ambiguous entries given context clues in surrounding entries of the new sorting, and test entries were removed. Conservative attempts were made to reconcile potential discrepancies noted in the first round of coding; that is, if there was remaining uncertainty as to accurate interpretation of an entry, it retained an "unspecified" designation and was not edited in any way. Entries clearly misattributed to a particular category were recategorized among category 1, category 2, and professional activity credits as indicated by the information provided.

Database quantitative analysis. Within the continuing education unit database, entries were sorted to analyze various descriptive statistics, beginning with number of entries submitted and total credit amounts for category 1 credits each year from 2002 to 2015 (entries submitted in 2016 were removed as the database was generated in June of 2016 and therefore represented a partial year only). Additional analyses were pursued based on findings of the CIQs and interviews – namely examination of in-person versus online learning activities; relative proportions of category 1, category 2, and professional activity credits; and top providers of category 1 credits.

Summary

This study integrated qualitative and quantitative data analysis methods to generate multifaceted views of professional learning of genetic counselors in response to innovation.

Table 6

Overview of Data Collection Methods

	CIQ, demographic inventory, and AT assessment	***Interview***	***CEU database***
Recruitment	Via email invitation to NSGC listserv	Via responses to demographic inventory of CIQ	Via ABGC data-sharing
Timeframe	Oct.-Nov., 2015	Mar.-Dec., 2016	June, 2016
Components	Demographic inventory Critical incident questionnaire Ambiguity tolerance assessment	Interview protocol	CEU database entries
Target recruitment	60	20	As available
Actual recruitment	**114 CIQs** (+ demographic information) **135 AT assessments** (+ demographic information)	**21 interviews** (20 completed CIQ)	**43131 unique entries** (total number of genetic counselors represented could not be calculated)
Completion	Online	By phone or in-person	Retrospective data
Analysis	Qualitative and quantitative	Qualitative	Quantitative

CIQs and interview transcripts were subjected to primarily qualitative analyses, whereas demographic information, ambiguity tolerance scores, and the continuing education database underwent quantitative analyses to inform further analysis of key qualitative themes. Table 6 above displays a summary of data collection and analysis methods, in chronological order of implementation from left to right.

Rationale for Methods

As professional development and continuing education of genetic counselors was not well studied, this study employed multiple data collection methods as well as qualitative and quantitative analysis techniques to generate rich and varied perspectives regarding this phenomenon. This study was designed within a pragmatic paradigm in which the primary focus is the research problem and all available means of addressing the problem are considered appropriate regardless of the philosophical system underlying the methods (Creswell, 2014). Indeed, in the context of rapid change, research on the learning of genetic counselors was well supported by a pragmatic paradigm which argues that “truth is what works at the time” (Creswell, 2014, p. 11) and mirrored the tactics of professionals attempting to keep pace with the field. Similarly, “the critical researcher, the bricoleur, the jack of all trades, produces a bricolage based on the use of many different interpretative practices and methodological tools” (Denzin, 2010, p. 423). It was this thinking which supported multiple data collection techniques. Additionally, though the genetic counseling profession was founded on quantitative research, qualitative research is gaining momentum (Beeson, 1997). “In rapidly developing areas such as clinical genetics, this interest in qualitative methods reflects recognition that often we don’t understand enough about the social dimensions of the phenomena under study to rely solely on quantitative methods" (Beeson, 1997, pp. 22-23); this study assumed a significant social component to the learning a genetic counselor initiates in response to innovations. Furthermore, as genetic counseling is a healthcare profession which draws upon the medical literature, it was encouraging to note that Alise and Teddlie (2010) studied mixed methods research and found that more than half of the mixed methods articles they reviewed were conducted in medical fields (p. 120). This suggests the chosen methodology was situated with the research traditions and extant literature of the field it studied.

As mixed methods research requires the collection and analysis of multiple data types and seeks to integrate them, validity considerations typically appropriate to certain types of data must be adjusted to account for heterogeneity of data collection and analysis methods. As such, authenticity and trustworthiness of qualitative data collection and analyses were assessed. Rodwell and Byers (1997) described authenticity as "attentive to the nature and quality of the research *process* rather than the research product. By focusing on the integrity and quality of the inquiry process, authenticity assesses fairness, ontological authenticity, educative authenticity, catalytic authenticity, and tactical authenticity" (p. 118). These subcategories of authenticity highlighted the extent to which research procedures identify, examine and prize the realities of all participants (fairness); promote complexity and depth in the understanding of constructions of interest (ontological authenticity); enhance the understanding of others' realities (educative authenticity); and promote action informed and empowered by the research act (catalytic and tactical authenticity) (Creswell & Miller, 2000). To achieve these standards for authenticity in the current study, efforts were made during recruitment to diversity the study's sample and attend to similarities and differences between the study sample as representative of the demographic spectrum of genetic counselors; ensure the qualitative data collection tools were sufficiently comprehensive (the main justification for inclusion of CIQs and interviews), prompted introspection, and encouraged action subsequent to participation; and monitor and audit data collection and analysis processes through the use of a researcher's journal and log of all analysis steps.

Trustworthiness, similar to reliability, is a criterion of goodness when assessing qualitative research findings in the constructivist paradigm. Trustworthiness reveals when data represent true reflections of the research participants' beliefs, experiences, or worldviews and can be checked by returning preliminary analyses of qualitative data to participants who might be interested in reviewing them. Coupling the CIQ and interview for individual participants, as well as consultation with colleagues in genetic counseling and adult education during analysis, was used to protect veracity of participants' views, challenge the researcher's assumptions, promote depth of understanding, and increase crosslinks between disciplines.

Overall, this study aimed to heed concerns that neither qualitative nor quantitative criteria for validity could be appropriately applied to evaluation of the study as a whole. Indeed, "pragmatists supplant coherence and correspondence with criteria such as accuracy, scope, simplicity, consistency, and comprehensiveness (e.g., Kuhn, 1977; Quine, 1970)." (Howe, 1988, p. 15). As strategies to address the research problem were identified, this study invoked simplicity (accessibility, ease of understanding), consistency (between various data sets, as a mark of coherence), comprehensiveness (embracing a range of alternatives), and applicability (feasibility of drawing on findings in similar situations) to assess the validity of study findings.

Limitations

There were several limitations to this study. The study sample was drawn from practicing genetic counselors in North America, a sample which, beyond geographic location, has a large degree of demographic homogeneity in terms of gender, age, ethnicity, educational background, and context of practice. Additionally, the study sample was dependent on subjects volunteering to participate – not once, but twice for those agreeing to be interviewed - which introduced self-selection bias and the possibility that findings were skewed by participants' interest in the general topic or strong viewpoints which instilled motivation to participate.

All study instruments utilized self-report of subjective opinions, perspectives, behaviors, and preferences; self-report is widely acknowledged to introduce inaccuracy and bias in responses. This study invited many genetic counselors to participate and engage with the topic through a variety of data collection techniques with the hope of overcoming biases such as resistance to providing written or verbal responses. This study also gathered a large, diverse pool of data such that, in aggregate, concerns of the limitations of self-report could be balanced with the strength and saturation of important themes throughout the entire dataset.

As responses to the CIQ and entries in the CEU database were anonymous, it was impossible to determine the extent to which CIQ respondents' CEU activities were reflected in the database. Though there was a concern such overlap would confound analysis, the size of the database intimates that any possible confounding effect would be diluted by the sum total effect of all entries.

All study processes – including data collection and analysis – were performed primarily by a single researcher such that these actions were subject to inherent and possibly unidentified biases. The researcher took steps to reduce the effects of these biases by persistently bracketing her assumptions regarding responses, consistently writing research memos regarding process, interpretive questions, and challenges, and keeping a research journal to serve as an audit trail of study activities and decisions regarding analysis. Memos included reflection on how the researcher's firsthand experiences were influencing perception of the data. Additionally, the coding scheme, coding calls, and emergent and developing themes were reviewed with colleagues in genetic counseling and adult education for critical discussion and external checks on the researcher's biases.

As with all research, this study was bounded by the theories upon which the data collection, analysis, and coding scheme were developed, namely that of learning from experience, community of practice, and continuing professional education. Such theories are themselves limited and challenged by lack of attention to the context framing perceptions and behaviors. This study attempted to reduce this limitation by building in iterative stages of analysis during which additional literature was explored and codes adjusted as needed in response to emerging themes. However, it was certainly possible that mistakes in the study's foundations could be carried through to findings and results.

Chapter IV

FINDINGS

Integration of critical incident questionnaire, demographic, ambiguity tolerance, interview, and continuing education database datasets yielded a high-level landscape of genetic counselors' professional learning in response to innovation coupled with detailed narratives of personal learning experiences. Findings related to each of the research questions – (1) how genetic counselors leverage learning to incorporate scientific innovations into practice, (2) what strategies and resources do they utilize for professional learning, (3) how colleagues influence professional learning, (4) whether professional learning varies by specialization or years of experience, and (5) whether ambiguity tolerance affects selection of strategies and resources – are described below. Themes revealed through qualitative and quantitative analyses were used to illustrate the collective experience of professional learning in genetic counseling, while intricacies of individual genetic counselors' experiences were best illuminated by inclusion of direct quotation of respondents' words.

How Do Genetic Counselors Leverage Learning to Incorporate Scientific Innovations into Practice?

In addition to detailed accounts of the process of professional learning, genetic counselors called attention to the context in which they learn and practice, consistently described as an evolving profession. They demonstrated a nested awareness of their personal learning experiences as examples of the functioning of the profession as a collective phenomenon, and further the profession as operating within a broader sphere of medical science. They further acknowledged that perpetual change in contextual features created conditions for constant professional learning. These themes – of an Evolving Profession and Constant Learning – were explicated through analysis of the interviews.

Evolving Profession

Interviewees emphasized the evolving, ever-changing nature of the field of genetic counseling. The rate of change was accentuated as being rapid, so rapid as to make long-term predictions of a career trajectory impossible.

> The field is changing so much… [it] is not going to be the same in five or ten years, so you can't have one type of position in mind right now, because that type of work might not exist in the same way in the future. (Lizzie)

Such rapid change generated significant uncertainty regarding the format, content, and context of future practice. Even in the near-term, the speed of change challenged efforts to keep pace through professional learning.

> Genetics, it's such a fast-moving field and people are always talking about how much we're learning so fast and how much research is doing and all these advances from exome… makes you feel like you have to keep up with it. (Kitty)

Interviewees frequently connected the concept of the rapidly evolving scientific foundations of the profession with a corresponding responsibility to attend to professional learning.

Constant Learning

Impressions of continual flux in genetic and genomic sciences were reflected in interviewees' commitments to constant learning: "I'm constantly trying to learn new things in keeping up with clinical outcomes and whatnot… there's definitely a continuous reminder that it is a constantly learning action" (Julia). Acknowledgment of change and the learning it implied were constant companions, bonded by a recognized professional responsibility.

The Process of Professional Learning

Themes regarding professional learning were organized into a logical schema of a chronological, cause-effect narrative (depicted in Diagram 4 below). The process of professional learning began when some type of innovation became available. Participants detailed their reactions to innovations and explained how these shaped motivations to identify opportunities for learning. A spectrum of learning strategies and resources were then utilized to enact the learning necessary to incorporate the innovation into existing practice. As learning occurred, participants named evidence suggesting their learning was effective and sufficient, which then translated into more extensive outcomes as they applied their learning to practice. Retrospectively, participants took perspective on the process overall to share generalized insights on their professional learning. Perspective-taking shifted to a macro-lens when participants examined messaging about professional learning relayed whither and whence various sources in the profession (such as professional societies or graduate training programs).

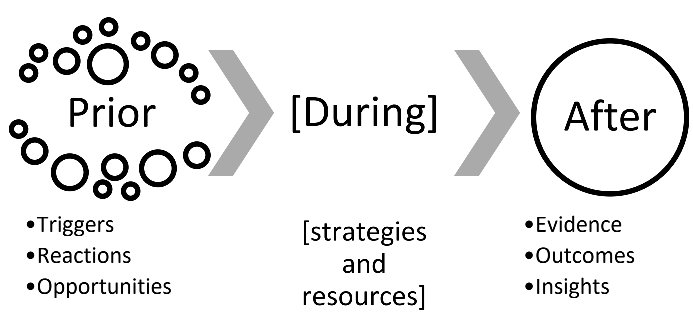


Diagram 4. The process of genetic counselors' professional learning.

Findings related to prior conditions for professional learning (Triggers, Reactions, and Opportunities), aftereffects (Evidence, Outcomes, and Insights), and messaging are reviewed with reference to the overarching question of how genetic counselors leverage learning to incorporate innovations into practice, while findings regarding strategies and resources invoked during professional learning are described in connection with the specified research sub-question on what learning strategies and resources genetic counselors utilize for professional learning.

Prior conditions of professional learning. Professional learning of genetic counselors was precipitated by several prior conditions. The learning process was initiated by a Trigger, often in the form of an innovation when it became clinically applicable but alternatively as a routine challenge of clinical work. Triggers were met with a range of Impacts - individual reactions, speculation on implications for practice, and impressions of widespread effects on the profession. The trigger and impact were then transmuted to enhanced attention for Opportunities for learning.

Trigger (innovation). Descriptions of innovations as triggers of professional learning fell into two sets: those related to Genetic/genomic technologies (populated by a variety of scientific advances, primarily testing methodologies) and Meta-trends (philosophically conceptualized as overarching trends).

Genetic/genomic technologies. When presented with the unspecified concept of “innovation” in the critical incident questionnaire, genetic counselors most immediately identified genetic and genomic technologies as triggers instigating shifts in practice. Next generation sequencing (NGS) – a testing methodology that enables testing of many genes concurrently and quickly - was most prominently featured as an important innovation along its application to the clinic through diagnostics: “NGS which [led] to development of large panel and exome studies. NGS also [led] to the deep sequencing on small specimens necessary for [non-invasive prenatal testing] NIPT and select oncology studies” (CIQ 15). The clinical applications of NGS technology identified by respondents varied predictably by specialty: non-invasive prenatal screening/testing (NIPS/NIPT) currently utilized for detection of common chromosome abnormalities in fetuses (along with three mentions of genome-wide NIPT as prescient insights into future iterations of the innovation cycle) pervaded prenatal/reproductive genetic counseling within the last few years; panel testing for hereditary cancer predisposition syndromes spread through cancer genetic counseling workflows within the same time frame; and whole genome sequencing/whole exome sequencing (WGS/WES) had become an increasingly common testing approach in pediatric/general genetics clinics. One participant cleverly described the shift in available testing as follows:

> Like dessert at the expensive restaurant - it used to be you would pick one, and carefully, and only on a very special occasion would you have more than one. Now it's like they just leave the whole dessert cart at your table. (CIQ 40)

This genetic counselor aptly noted that NGS technology, in expanding the scope of what a single test can detect in a similar timeframe and for a commensurate cost, altered strategy used to seek a diagnosis in a way that was experienced as indulgent by the provider.

Meta-trends. Several genetic counselors offered alternative framings on innovation; instead of genetic/genomic technology, they viewed innovation as a confluence of events or ongoing evolution. These participants qualified the mention of technology by pairing it with the Supreme Court’s decision to strike down patents on genes: “the advent of NextGen sequencing and the de-patenting of genes" (CIQ 233), suggesting shift in practice was precipitated by a combination of factors, including societal events.

With similarly expanded thinking, others refrained from naming a single technology as innovation and instead described a perpetual process of change, as "innovative small steps are always happening" (CIQ 15). Some viewed the series of changes as quite expansive: "there have been so many major paradigm shifts (one gene=one protein, parental imprinting, discovery of genes for HBOC, Next-gen sequencing, SNPs" (CIQ 235). Others limited the sense of perpetuality to technology only: "DNA testing - Southern blots to the first DNA point mutation testing for CF in 1987, to more and more and more tests and Sanger to NGS... exome testing..." (CIQ 215).

Nearly all respondents named genetic/genomic technologies – either alone, in combination with societal factors, or as instances a continuous, conceptual theoretical string – as innovations prompting shifts in practice.

Impact. Participants attributed a multitude of effects from innovations, impacting both themselves and practice. Descriptions of these effects were collated under the theme of Impact. The Initial reactions/perceptions subcode differentiated individual responses – often emotive – to the innovation, while statements describing perceptions of broad or general impacts of a given innovation were assigned the Magnitude subcode. An Implications for practice subcode was used to aggregate statements about practical or pragmatic consequences ensuing from an innovation.

Initial reactions/perceptions. As innovations arose, respondents described a variety of thoughts and emotions. Many genetic counselors experienced excitement. For some, the excitement resulted from being on the cutting edge: "It made me feel like I was participating in the latest and greatest for clinical genetics" (CIQ 76). For others, excitement was associated with the chance to enhance current practices: "Felt like a new, exciting technology to solve some long-standing dilemmas" (CIQ 69). Others experienced apprehension, primarily regarding attendant unknowns: "the large possibility of challenging-to-interpret results and the 'can of worms' that we may unleash" (CIQ 62) and "what was being ordered without complete knowledge of what the results mean" (CIQ 106). The element of uncertainty engendered awareness of a lack of the necessary knowledge or skill to navigate the innovative technology and recognition of a need to learn.

> I think there was just a big lack of knowledge/studies/validations/experience regarding NIPT that it was something that I felt needed to be learned on the go and required a lot of anticipation of all the things that could affect it, go wrong, etc. vs. knowing what can happen based on literature/experience, etc. (CIQ 85)

This respondent articulately related the confusion of working with cutting-edge technology in the absence of supporting data and formalized resources.

A feeling of being overwhelmed by the scale of expanded options and information – "too many labs, too many nuances with insurance coverage, and too little data" (CIQ 19) – seemed to exacerbate the inherent complexity of extant practice.

> I often felt that in the current clinic setting crunched for time as the complexity of genetic tests increased and also that there was not nearly enough time for a patient to gain a true understanding of what all could come from this type of exome testing. (CIQ 256)

This respondent highlighted the complexity of innovations for both the provider incorporating it into an already busy practice and for patients making decisions about whether to pursue testing and incorporate results into their care.

Considering the implications of innovations for patients was featured in several responses – fitting from individuals working in a helping, healthcare profession.

> We had previously been ordering single gene testing and some panels which were often not big enough or affordable enough, so this technology offered a lot of new hope and opportunity for the patients, and therefore to me as a clinician as well. (CIQ 220)

Some respondents saw hope for patients from the new testing: “I am so grateful for the families who have received an answer from a gene panel who might not have had an answer before, this innovation is powerful and has so many benefits” (CIQ 105). Others remained concerned that “patients would not give true informed consent to be tested” (Response 64) given the complexities and uncertainties related to new, expanded testing options.

Other reactions included a pressing motivation to learn: “As the NGS-based genomic testing was just entering clinical diagnostic setting, I felt the urgency to better understand the new technology and the impact of new testing technologies on potential changes in the clinical setting.” (CIQ 58). This elevated energy level was equally reflected by those who viewed innovation as an opportunity to explore fresh territory. One respondent described “each case [as] a new adventure” (CIQ 90), and another felt that “this learning curve was steep for me, and while challenging was welcome” (CIQ 92). This eagerness was not universally endorsed, as one respondent nostalgically mused, “I find myself wishing we could simplify things again” (CIQ 261).

Participants’ initial reactions to innovations highlighted the disconcerting nature of new technologies; they were by turns excited, apprehensive, uncertain, overwhelmed, hopeful, and curious. Participants’ seemed to translate their reactions into motivation to pursue professional learning, yet there was some suggestion of the motivation being complicated by complexity of both the innovations and reactions to those innovations.

Magnitude. It was not uncommon for participants to extend individual sentiments to generalized opinions about the impact of an innovation on the profession generally. These statements tended to be of a sweeping nature: “Basically the entire field changed because of this new method” (CIQ 238), “The conversation about testing changed dramatically with gene panel introduction, as did the work outside of the session” (CIQ 105), and “All of these have had tremendous impact on prenatal genetic counseling” (CIQ 12). The perceived magnitude of an innovation was presented as immense and profound in these instances, emphasizing the extensive impressions innovations left on individual practitioners.

Implications for practice. Genetic counselors, in reacting to innovation, identified multiple implications for their work, beginning with acknowledgement of the need to adapt, through reflection on potential adjustments to practice, and into awareness of complexity as a factor suffusing their experiences.

Participants acknowledged innovations had direct implications for their work and acknowledged the need for adjustment:

> I had to find ways to modify my counseling to be able to address all the possible topics that can come up regarding screening, and to do it in 40 mins without compromising psychosocial counseling and focus on my patients needs and desires. (CIQ 85)

As innovations became clinically available, they were added to the array of available diagnostic tools and required adjustment to several aspects of the genetic counselor’s case management strategy: the informational content of a patient encounter for the purposes of decision-making and informed consent – including particular topics, tools, or explanations or tweaking the level of specificity or vagueness of descriptions; regulating the purposes of pre- and post-test sessions for the effective and efficient use of limited time with the patient; and revisiting philosophical orientation to patient care, balancing psychosocial and scientific components.

Adjustments were described as a process requiring personal acceptance or buy-in: “After my own period of adaptation (!) and the introduction of clinical exome sequencing, it became clear that we were going to keep going in this direction of content and I needed to engage with it more fully” (CIQ 105). Embracing the need for adjustments to thinking and action took time, as did the process of adapting; once accepted, acknowledgement initiated an adaptive process of learning and updating practice. One respondent outlined the progression of adjustment from initial recognition to implementation with respect to particular tools for practice:

> It took me a while to understand the implications of these new tools… I have since learned to use these tools (with limited instruction, mostly self-learning) and have found them incredibly useful. I have used them in my practice when counseling patients about results to explain the evidence for or against a variant (or the lack of evidence). (CIQ 324)

Another explained shifting the purposes and time allotments of pre- and post-counseling sessions:

> I was working in a clinic at the time and this changed the way I approached family histories, and the way I counseled. My pre-test counseling became shorter and less syndrome-specific and the post-test/results counseling became longer and the place more appropriate to discuss the in-depths of syndromes. (CIQ 242)

While many adjustments appear to lead to new, effective behaviors, others were conceded with a sense of loss.

> This perspective crept in from both the clinicians and the patients, and what used to be sequential visits over a longer period of time--far more conducive to working with people around adapting to life with a particular disorder--quickly became only 1-2 visits to do testing with large panels and then discussing results. (CIQ 105)

To some, adjustments following innovations remade previously collaborative interactions into procedural exercises bereft of relationship and connection. The increasing complexity introduced by innovations seemed, by some accounts, to strain the existing patient-genetic counselor rapport through sheer volume of topics to discuss in limited time and the untenable ambiguity which accompanied it.

Initial reactions, statements of magnitude, and speculation on implications for practice constituted participants' perception of the impact, both personal and on the level of the profession, innovations had on genetic counseling. Many reframed the impact as creating motivations for or chances to learn.

Opportunities for learning. When thinking of impetuses for professional learning, interviewees acknowledged practice as presenting important and continuous opportunities for ongoing learning - "if not a day by day, hour by hour learning process of different nuances of different teams and of different workflows and policies" (Mariah). This clarified that innovations alone were not as potent at initiating learning as were circumstances in which innovations were incorporated into patient care. Respondents to the critical incident questionnaire described professional learning inspired by innovations, whereas interviewees related learning in response to quotidian challenges of a typical day's work. Additionally, structured learning activities such as national conferences, case conference, and journal club were noted as reliable learning venues by both respondents and interviewees.

Practice. It was quite common for genetic counselors to describe their work as presenting opportunities to learn. Interviewees framed patient care as a strong motivator of professional learning; serendipitous cases were viewed as precipitating learning by highlighting gaps in their existing knowledge base. They turned to learning to address these gaps and help them accomplish routine aspects of patient care as well as other tasks related to their position. One interviewee described practice's prospects for learning in this way:

> When I have these epiphanies that I want to either participate in somebody's medical care – especially if it's a multidisciplinary care – or I want to explain something that's a little bit out of my comfort realm to people, what I end up realizing is that I don't really know as much as I think I do. And so I end up having to learn. (Charlotte)

She noted that her motives to work in certain ways or at certain tasks revealed weaknesses in her understanding that required redress before she could realize these self-identified goals. Other interviewees corroborated the experience of practice revealing gaps in their knowledge:

> When you have a patient that comes in and something's unclear and you have to go dig for who knows what – whether it's testing or outcomes or what a variant means or things like that. It's really that direct patient interaction, whether it be from another [referring] physician or the patient specifically, it's those pieces that are unclear that really make it clear that we are needing constant learning and bettering ourselves through that. (Julia)

Conducting case preparation for an unfamiliar indication or reason for referral, researching the benefits and limitations of testing, interpreting an unusual result or variant – these are all typical tasks of genetic counseling practice, and all tasks interviewees identified as opportunities to engage in learning facilitated by the unique motivation that comes from wishing to care thoroughly and well for others.

Beyond patient care, interviewees named other job-related tasks or roles for which they prepared by learning. When giving a presentation, developing a research study, or teaching, interviewees noted opportunities to engage in professional learning. One genetic counselor described a distinctive learning experience prompted by an administrator:

> I've been asked to start a company and so I was learning about different funding mechanisms with a start-up company versus going through a more traditional route with grants and how to differentiate whether you actually want to start a company versus do a research project and get alternative funding. (Fanny)

Her institution requested that she consider spearheading an initiative related to one of her existing roles; to better assess this new opportunity, she applied her professional learning practices to the topic of funding sources.

Several interviewees engaged in teaching as part of their work as genetic counselors. Teaching was appreciated as an expedient means of initiating professional learning.

> I think when you're in a position where you're teaching, it makes you more on top of what you need to learn also… [You] want to give them information that's current. And not just an impression of something, you want to give them accurate information because hopefully they'll take that somewhere else. And if you say, "Well, yeah, kind of… Most of the people with this syndrome have a heart problem," that's not going to be as helpful to them as saying, "When cardiologists see SVAS [supravalvar aortic stenosis], they know to refer to genetics because that's the most common problem in Williams syndrome. (Jane)

Jane, through her role as an educator, pinpointed information needed for effective care by first analyzing her own understanding of the topic. She considered her own and others' perception of the information and potential gaps, then settled on the level of detail necessary and sufficient for learning outcomes she deemed useful – specifically an understanding (not an impression) which could be transferred to other contexts. She then characterized her responsibility to impart accurate, detailed information and proceeded to procure and learn that information for herself and others via teaching.

Genetic counselors routinely encounter opportunities to learn through their work. Patient care presents scenarios and information not previously encountered, some of which result from innovations; each case demands a personalized approach which requires researching case-specific questions. Other work responsibilities such as responding to requests from administration or teaching present chances to utilize learning to examine, expand, and deepen existing expertise. All were perceived as opportunities for and instigators of professional learning for genetic counselors.

Structured activities. As a complement to professional learning embedded in the practice context, participants cited several forms of structured learning activities as opportunities for professional learning: "The obvious ones are when we have group journal clubs or case conferences – things like that where it is that structured, scheduled time" (Lucy). National conferences or conventions, departmental case conferences (collaborative analysis of interesting cases), and journal club (collective interpretation of new scientific literature) were common examples. One interviewee described these events like so:

> I am fortunate to work at a hospital and in a department with other geneticists and genetic counselors, and every Friday we have what we call our case conference where we present difficult or challenging cases or just bring up new information that somebody might have learned about. That's when I know for sure that I'm learning and brushing up and keeping up-to-date on information. (Susan)

For Susan, case conference introduced her to the latest information in a social environment that enabled her to recognize she had an opportunity to engage in a learning process. As was noted by other interviewees, case conferences and journal clubs typically occurred on a regular basis, suggesting structured learning events were embedded in the work schedule.

Another interviewee, Margarette, made an interesting distinction between practice-based learning and structured learning activities: "I think the learning probably happens every day and you only go to a conference once a year, so you know, I think about what am I learning… I don't think I learn things once a year at a meeting" (Margarette). Many interviewees easily acknowledged structured activities as learning opportunities; however, when calculating perceived frequency of learning, the prominence of practice-based learning was more readily perceived.

Findings illustrated genetic counseling practice was in a constant state of flux due to serial innovations in genetic and genomic testing technologies. Innovations expanded the number and type of testing options, which genetic counselors found overwhelming at times. They initially reacted to innovations with excitement at the potential benefits for patients, and apprehension about lingering unknowns and lack of data. They perceived innovations as adding complexity to their work. Despite initial disorientation, genetic counselors quickly enacted professional learning to address and resolve the uncertainties and ambiguities surrounding innovation by adopting strategies and resources detailed later in this chapter. Participants explicated several aftereffects of professional learning, namely indications their learning was effective, practical effects of their learning, and insights on their learning.

Aftereffects of professional learning. Participants were aware of and able to describe aftereffects resulting from their professional learning – Evidence, Outcomes, and Insights. They gave examples of Evidence which they used to determine whether their learning was effective in helping them to address a particular gap or need. They pointed to Outcomes when their learning was infused into their approach to practice. Participants subsequently took perspective on the process of professional learning in its entirety and shared Insights on their learning experiences.

Evidence of learning. After investing considerable time and effort into the learning process, interviewees discovered gratifying evidence of the efficacy of their learning. The most commonly cited evidence of learning was the Ability to explain what they learned to others; gaining New perspective was another bit of proof that learning had occurred.

Ability to explain. Interviewees frequently stated that they recognized they had successfully completed a learning process when they were able to explain their new knowledge to others, as one interviewee said, "when I feel like I've reached a comfort level where I can discuss it with other people" (Jane). The sense of comfort arose from acquiring competency – a new packet of knowledge, skill, and/or attitude:

> I would assess that I've learned what I needed to learn when I'm able to talk about it without having to refer back to resources and I'm feeling comfortable with the information and I can convey that to whoever else that needs to be, whether it's the administration at my own facility or at the hospital setting. And so I feel like I've done my due diligence that I truly learned it when I'm able to talk about that efficiently and correctly, based on these things I've learned from either literature or from the other clinics… Once I'm able to have those comfortable conversations with patients and I'm not having to constantly look things up, that's when I feel like I've kind of grasped what I needed to [at] that point. (Julia)

Knowledge had been acquired and could be applied easily and to various audiences directly from internal reserves rather than revisiting the learning process or returning to resources. A comparable piece of evidence consisted of leaving no question unanswered: "I guess when I don't have any more questions for myself and then that's reaffirmed if I ever have an opportunity to share that information" (Marianne). The observation of having no questions indicated the learning had produced a proficiency sufficient to sharing that knowledge with others. Indeed, when the recipients of the explanation also had no questions, it was taken as further evidence that learning was complete:

> When I spoke to the family and I felt like I could answer the questions they asked, and they were asking really good questions. Some questions I could answer because I knew that we don't know that information. But pretty much most of their questions I could tell them the answer to and I didn't feel nervous in the sense that, "What if they ask something that I should know and I don't know?". (Kitty)

Here again, Kitty showed the comfort that comes from both having the answers and knowing she had the answers as evidenced by her ability to explain her learning to others and leaving no questions unanswered. Interestingly, she specifically pointed out the comfort of knowing when there is no answer and framed that as an answer in itself.

New perspective/insight. While ability to explain was an essential piece of evidence that learning had occurred, it was not the only one. Several genetic counselors recalled awareness of developing a new perspective as confirmation of their learning. One interviewee suggested that she was not often aware of the results of her learning:

> I'm a fairly new genetic counselor, I've only been working for about a year and half now, and when I think back to a year ago, I can think, "Oh wow, I didn't even know about that resource" or "I didn't even know about this particular condition" or "I didn't even know that this could affect a patient" or "I should be thinking about this with patients" and now I'm like, "Wow, I've really learned a lot!"… But in my day-to-day life and work, I don't notice those professional growth changes. (Susan)

Susan explained that only by referring to a previous version of her professional mentality could she see that shifts had occurred. When she made the comparison, though, the extent of her learning, development, and growth was set in stark relief. The learning process was gradual and granular in a way that eluded more frequent or direct recognition.

Many interviewees believed the ability to explain new information was prime evidence that learning had occurred and was successful. Being able to answer questions as they arose without turning to resources was put forth as further evidence of this ability. For others, it was difficult to identify incremental evidence of learning; overall growth was marked on a longer timescale by comparison with earlier points at which the learnings had not yet occurred, generating a new perspective on one's overall knowledge and skills.

Outcomes. Genetic counselors identified distinct outcomes as their learning was applied to their work. The most prized and significant outcomes were those with Practice implications, such as modification, adjustment, or enhancement to counseling approaches or testing strategies derived from the learning processes. Beyond tweaking discrete aspects of practice, participants also described professional learning as producing a state or mode of work that recognized and leveraged Perpetual change.

Practice implications. Learning conducted by genetic counselors frequently had implications for their practice in terms of changing their approach to counseling patients or altering their strategy for ordering testing. Respondents to the critical incident questionnaire identified several ways in which they changed their approach to counseling patients subsequent to learning. The process of decision-making was a key target of adjustment. One respondent, due to the increased number of conditions tested concurrently by a new panel test, described how she could no longer provide in-depth education on all included conditions: "My counseling has focused more on facilitating decision-making versus pre-test education about specific hereditary cancer syndromes" (CIQ 247). She adjusted her approach to patient decision-making by drawing the patient's attention to the process – rather than the content – of testing. Similarly, another respondent explained an analogous shift:

> In the past, when engaging in an informed consent discussion with a client, I was very specific about the gene/condition pair being examined, as well as the outcomes of the test. Now, I find that my discussion is focused around making sure the patient consents to a testing process rather than a particular gene test and a range of possible outcomes. This is especially true when discussing incidental/secondary information from exome sequencing and genes on panels with less clear actionability. (CIQ 68)

The volume of information related to tests which incorporate multiple conditions (the challenge of multiplicity introduced by the complexity of an innovation) made it infeasible to structure the discussion about testing in the same way as previous testing which incorporated one condition. As such, the genetic counselor moved to a more general orientation and spoke about features of the testing process in contrast to details about a particular test. For example, testing for hereditary breast and ovarian cancer syndrome previously interrogated two genes: BRCA1 and BRCA2. Genetic counselors relayed gene function, associated cancer risks, management recommendations, logistics of testing, possible results, and implications for relatives with respect to each gene (and for several of these components, the two genes were similar if not identical, allowing for one explanation to suit both genes). Currently, testing for hereditary cancer risk may include upwards of 30 or more genes; there simply isn't time to include the same level of detail for each of 30 genes. Therefore, respondents indicated that pre-test discussions instead focused on the concept of inherited cancer risk, logistics of testing, and possible results ("I find myself being much more general in my pre-test counseling" [CIQ 18]) while details of gene function, associated cancer risks, management discussions, and implications for relatives were reserved for post-test disclosure sessions when these could be tailored to a specific test result ("I focused more of my counseling on the back end rather than spend all that time on the front end when I didn't have a result to talk about with the [patient]" [CIQ 88]).

Through constantly changing and increasingly ambiguous circumstances, genetic counselors changed their counseling approaches as adaptive responses to innovations which complexified their work. They did so by shifting attention from the informational content to the process of decision-making, or from specific details to general concepts. They did this frequently because they recognized that innovations changed the contexts within which they operated on a regular basis, and typically made practice more challenging.

To complement the change in approach to counseling patients about new testing technologies, respondents acknowledged that their learning led to altered testing strategies. For some, the more they learned about a new test, the less likely they were to order it – they became conscientious objectors: “We have been critical of the marketing of this test and refused to offer components that we do not feel are scientifically sound” (CIQ 63). In this case, learning resulted in rejecting innovative testing in favor of existing testing options. Alternatively, others progressed toward routinization:

> It was a gradual change from learning about [non-invasive prenatal testing] NIPT, to offering it to select patients, to offering it to more patients who fit certain criteria, to trying different labs that provided the test, to (finally) feeling comfortable with it all. (CIQ 91)

In stepwise fashion, this genetic counselor explored discrete components of a new testing option: the test itself, target patient populations, expanded criteria for appropriate recipients, and variation in suppliers. The learning was careful, purposeful, and likely time-consuming yet reached an end state of a new standard practice: “we utilized it ALL the time, shifting our workflow in the department” (CIQ 64).

Altering standard practice in this way was noted to influence other aspects of practice, particularly the average number of encounters needed per patient to complete assessment and testing procedures: “Instead of offering single-gene testing and having to have patients come back and submit another sample if their first genetic test was negative, I am offering and ordering multi-gene panels for the majority of my patients” (CIQ 16). With the ability to test for all indicated conditions concurrently, the need for serial visits was reduced, as was the time between testing and the end result.

Perpetual change. Because of professional learning, respondents found themselves in a state of perpetual change; learning became the means and the end.

> I keep thinking "we've done it, we've figured it out!" and then I'll get another random result I wasn't expecting. I think innovations force us to be in a constant state of evolution with our practices. Things change overnight and sometimes you can't always keep up. (CIQ 57)

The intention of reaching a destination gave way to recognition that the journey was continuous and ongoing.

> Change happens (continuously) in genetics. We must adapt to new and transformative/ disruptive technologies, but we must be deliberative and proceed cautiously to avoid listening to the hype and, sometimes, misleading spin of sources that may have a bias or potential conflict of interest. (CIQ 228)

The pace of change and messages related to innovations could be daunting and obscuring, yet respondents perceived these as further justifications for learning.

> Although I've always considered myself a self-motivated learner, this particular point in time and steps taken clearly showed me how critical it was to prioritize and actively seek such learning opportunities above and beyond what was available in a relatively informed/advanced setting, as the technology was changing faster than the knowledge was coming through into clinical practice. (CIQ 58)

Learning was a professional responsibility that had to be actively and perpetually fulfilled in response to innovations as they arose.

The notion of perpetual change was invoked with reference to aspects of practice as well: “My approach to counseling about this is always changing, as the test itself is always changing, and each lab that offers it is a little different in one way or another” (CIQ 261). This respondent identified with a nimble philosophy of practice which adapted to the context in which it occurred. Another respondent connected change to counseling about screening with increased complexity: “It has definitely changed how we offer screening. It is not quite so simple as [maternal serum screening] MSS or amnio[centesis] anymore, not so clear cut as ‘high or low risk’" (CIQ 261).

Participants provided multiple examples of their learning effecting outcomes in practice – as a change in approach to counseling during the patient encounter, in alteration of testing philosophy or strategy, and as an expanding consciousness that constant change was in fact a key feature of the steady state of their work. Their perceptiveness when listing outcomes was applied with equal sophistication to elucidating Insights regarding their professional learning experiences and preferences.

***Insights*.** In describing experiences of professional learning, participants readily unearthed pertinent insights regarding the process and their preferences. Insights took two main forms: Impediments to changing practice, which included challenges encountered during the learning process, and Lessons on learning, which reflected perspective-taking on one's own learning, practice, or self.

Impediments to changing practice. Participants, in musing on challenges to incorporating innovations into practice, accentuated the importance of perception. That is, a primary impediment to change was resistance whereas – reciprocally – acceptance was an important facilitator.

> I'd say just the willingness to accept it was the most helpful. Once I stopped hemming and hawing about whether to do the panels or not and to just start offering them, I found it to be a lot easier than I'd feared it would be. I spent so much time worrying about it that I was making it seem more difficult and complicated than it actually was. Once I just accepted that I'd see it through no matter what, it came a lot easier to me. (CIQ 104)

This respondent declared that her initial resistance was unfounded and, for a time, obstructive. Acceptance of change and innovation allowed her to move forward with professional learning. While this respondent named the target of her resistance as the technology itself, another discovered it was not the innovation but the profession's reaction to the technology that she resisted:

> For a long time, I tried to avoid learning every detail of this new testing approach. In retrospect, this seems to have been my response to the shift that I began feeling in the field toward GCs becoming content experts and not process experts. (CIQ 105)

Her learning was blocked by her perception that genetic counselors were being pushed to be information-focused experts rather than facilitators of patient-centered decision-making.

Lessons on learning. Genetic counselors demonstrated introspection and self-awareness when reflecting on their experiences of learning. For example, in contrast to impediments to professional learning noted above, the following respondent expounded on the utility of openness:

> I think the most important step I took was to be open, and willing to learn as much as possible about as many new testing offerings available: this gave me a depth of information that I could use when justifying my testing strategies, and the options available to patients and their families. (CIQ 249)

Being open to change created an avenue by which genetic counselors took in information and formed new opinions. Another respondent extended this idea of gathering information by emphasizing a cause-and-effect abundance of accessible learning resources:

> As new innovations become available in our field, there are many resources that become available to help you learn them - conferences usually focus on the newest things, webinars become abundant. It is important to use these resources as much as possible, as it's much more difficult to learn these things on your own. (CIQ 324)

Not only must one remain open to change, but also to learning opportunities which accompany the change; this suggested that genetic counselors saw circumstances as conspiring to support learning about an innovation, easing the burden of constructing a learning process independently.

Genetic counselors extracted other useful insights regarding their practice when recounting their experiences with innovation and professional learning. Some simply declared a realization that it was possible to incorporate innovations: “I learned that we can add new technologies like this without significant burden, once the education is done and the application is allowed to play out clinically" (CIQ 14). Another accentuated that innovations challenge the philosophical foundations of practice: "In retrospect, this was a real lesson in determining what is the truly important education content with more emphasis on counseling/decision making" (CIQ 75). There was also recognition of the constancy of change ("I learned that as much as I think 'things have always been done this way', there is always room for improvement and innovation" [CIQ 238]) and that functional adaptation to change involved remaking the framework of practice ("we needed to come up with a new style, instead of trying to cram the new tests into our old schedules/formats" [CIQ 336].). And they viewed change as a forward march to complexity: "I learned that as technology advances, clinical genetic becomes more complex, not simpler" (CIQ 27).

Respondents demonstrated perspective-taking not only on their work but on themselves as professionals. They owned new character traits acquired through learning: "The most important information I learned from the process was how to be flexible, rather than stubborn, when new strategies or options are discussed" (CIQ 249). They experienced a growing comfort with the uncertainty surrounding novel technology and its many unknowns ("I have learned to become more flexible and more comfortable with uncertainty" [CIQ 247].) and connected this comfort as an outcome of prior professional learning ("I learned how to research and stay up to date to ensure I'm appropriately informed, and now I am much more comfortable with the uncertainty in GC" [Response 13].). Indeed, one respondent stipulated that her own development was intertwined with that of the profession:

> The most important thing I learned from the process was that I am co-evolving with the practice of genetic counseling. The field impacts me and I impact the field.

> While I would never have predicted that I would be doing what I am now, when I look at it in reverse the path that brought me to where I am makes perfect sense. (CIQ 105)

She accepted the blindness of foresight yet embraced the rationale of retrospect, seemingly having found herself in relationship with her work.

As a result of professional learning, many genetic counselors achieved a state of perpetual practice change – adjusting their counseling approaches and altering testing strategies – in which the rate of change in their practice was commensurate with the rate of innovation in technologies. Along the way, they gained insight into the challenges and facilitators of their professional learning, their practice, and their evolving professional identities. Many were able to contrast their personal perceptions with messaging they received from multiple sources within the profession, particularly professional societies and graduate training programs.

Messaging. Interviewees described a culture of lifelong learning in genetic counseling, reinforced by messages conveyed through professional societies and training programs and promoted throughout the profession generally. Interviewees received impressions that professional learning is "of value, it's an important thing to do, to spend your time doing… and that it is very fair to be colleague-dependent" (Caroline). The importance of professional learning was tied to perceptions of the field as fast-paced and perpetually evolving:

> A lot of people talk about how genetic technology and how we're setting up services to help people are constantly changing. So, I actually think it being framed that way by the professional societies and by people who are big in genetic counseling is helpful in giving the message to all of us that you better stay on top of it. (Jane)

Professional societies, especially the National Society of Genetic Counselors (NSGC), were viewed as encouraging and supportive of professional learning by providing many, varied learning opportunities.

> I feel like NSGC has really made a concerted effort to make learning opportunities available to the members and has seemed to embrace a lot more webinars and they've had the journal club for a long time. I feel like there's really a multitude of ways to access the learning opportunities. (Betsy)

Not only did professional societies provide learning resources, they were appreciated for diversifying their offerings to accommodate members' preferences, needs, and constraints.

In addition to support engendered by professional societies, the profession as an overarching entity was presented as supportive of learning through nurturing a culture of collaboration. Interviewees commented on the cooperative feel of the field:

> I feel like in general, we have a very collaborative profession. Certainly with genetic counselors and even into the medical genetics broader profession inclusive of geneticists, so that collegial and collaborative environment has made it really easy to feel like you can reach out without fear of being judged, that "Why don't you know this already?" I think there's recognition on all of our parts that none of us can know it all. (Betsy)

The sense of cooperation stemmed from the understanding that all members of the community had similar learning needs and goals, which removed potential stigma around asking questions and normalized learning. Interviewees stipulated that acceptance of ongoing learning was instilled during graduate training:

> I think that was ingrained in me in my training program as we're training to be a lifelong learner… More of a culture or a mindset, that you're never going to know it all, you're always going to be continually learning, these are the foundational skills that you need to be a lifelong learner. (Susan)

The culture of learning within the profession – introduced during training, reinforced by professional societies, and felt through the profession ethos – was linked to recognition of a challenging practice context replete with demands for new knowledge and skills. While this promoted acceptance of constant learning as normal and necessary, some pointed to a potential tension between professional learning as desired versus required endeavor.

Desire versus require. Several participants distinguished between desired versus required learning, a theme identified broadly throughout the interviews particularly in connection with discussion of continuing education credits as the recognized currency of professional learning related to certification. Some accepted the need for required professional learning in the form of CEUs given their belief in the overall import and utility of such learning for ongoing quality practice. Others were somewhat resistant to being compelled to learn: "It's sort of like you have to do it and it shouldn't be a chore, it should be, 'Wow, this is cool, this is fun, this is why I love what I do!'" (Anne). This quote was representative of the group of interviewees who stressed a commitment to enjoying learning per se. They wanted to maintain a sense of learning as a desirable activity, one they felt was autonomously enacted:

> Choosing what I want to learn versus just learning what comes my way... So when I'm in my day-to-day work, I'm learning all of the time, but I'm learning what comes across my desk and what happens to come my way, which is all fascinating. But I would say, in my mind, it kind of separates from doing the professional learning where maybe I know I have a weakness in this area that I want to improve on, I want to learn more about. (Susan)

These interviewees seemed to be protective of internal motivations to learn and resisted external motivations in the form of requirements and regulations.

Genetic counselors relayed remarkable awareness of professional learning. They contextualized their personal learning experiences as unique examples of adaptation within the profession in a state of evolution; they changed along with the profession, absorbing innovations – all aspects shifting through constellated interconnections. This expansive conceptual perspective was accompanied by deep discernment of elements of the learning process: prior conditions which activated, strategies and resources which facilitated, and aftereffects which resulted from their learning. The strategies and resources enacted by genetic counselors during professional learning are those to which this examination now turns.

What Strategies Do Genetic Counselors Utilize for Continued Professional Learning?

Participants cited an impressive assortment of strategies and resources utilized for professional learning. Attending to distinctions between formalized learning activities and more implicit learning encounters embedded in participants' narratives such as accounts of frequent, subtle learning opportunities presented by practice or awareness of new perspective emerging as evidence of learning over time depicted in the previous section, learning strategies and resources were delineated by reference to two categories: formal, structured, explicit learning activities as contrasted with informal, intuitive, implicit learning activities. These categories were corroborated by the theme of distinguishing between formal and informal strategies arising from the interview analysis.

Formal Versus Informal Learning

Interviewees differentiated formal learning as structured activities with explicit goals of producing learning from informal learning related to unplanned encounters with colleagues or circumstances arising from practice; they noted that formal learning occurred periodically whereas informal learning is near constant.

> Probably at least once a week we'll do some kind of learning opportunity, whether it's an online webinar or a grand rounds presentation or something formal. Now, informal learning I think happens every day because oftentimes, we'll be like, "Hey, did you read this article? Did you see this? This came out, that came out. What do

> you think of this?" So I would say there's both formal learning opportunities and informal. (Charlotte)

The nature of such encounters with colleagues were categorized as more informal because they were unplanned and occurred spontaneously. One interviewee noted difficulty of identifying more informal, practice-based learning, hinting at its implicit quality:

> I think professional learning probably happens all the time and I don't think it's always as formal… I think that's why I'm having trouble thinking of examples is I don't view it in a very formal way, but I think it's probably happening on a very regular basis. (Margarette)

In this case, the informality of learning embedded in practice escaped notice and eluded definition. Of note, it was often in considering frequency of experiences of learning that interviewees were drawn to consider practice-based learning, as they felt it was an underestimate to say they were learning weekly at structured activities or annually at conferences. Tacit impressions of learning constantly and informally were described in contrast to less frequent formal learning activities.

Formal, structured, explicit learning strategies and resources. Genetic counseling in part consists of translating complex science to accessible language to facilitate patients' informed decision-making, a task of an intellectual ilk. The significance of this task was reflected in the emphasis participants placed on seeking formalized information through reading and researching, attending lectures and presentations, and participating in structured learning activities such as conferences. Facets of formal, structured, explicit learning strategies beyond those found in participants' accounts were explored through analysis of a database on continuing education units (credits assigned to professional learning activities for the purposes of certification and licensure).

Reading and researching. Considering genetic counselors' training in analyzing scientific literature and that many aspects of practice (information exchanged during patient education, delineating options for testing and management) are constructed on evolving sciences, it was unsurprising that participant confirmed reading and researching as core strategies for professional learning.

Respondents to the critical incident questionnaire endorsed reading as a favored learning strategy. Innovations are often technical and compelled participants to gather additional information and develop new knowledge regarding methodologies, applications, and limitations. Genetic counselors acquired this knowledge, in part, by reading the primary literature. "The world of genetics changes so quickly that it is really important to read, read, read (till your eyes hurt - read) … so you can glean the most up-to-date accurate information possible" (CIQ 230). They read "relevant publications, especially regarding practice guidelines" (CIQ 345), empiric studies, articles of all kinds – "familiarizing with information that patients could find online, therefore would understand what information they had available to them" (CIQ 226). They gathered "resources available on PubMed and articles shared by professional organizations, like NSGC" (CIQ 87) when conducting literature searches to synthesize their findings.

Interviewees validated the strategies explicated by respondents to the critical incident questionnaires. Multiple outlets were listed as portals to the information they needed: "GeneReviews, UptoDate, places where I can find reliable information… then I'll look more deeply into the primary literature sources – I usually use Google Scholar to do that" (Caroline). Betsy laid out a similar process:

> The internet is our go-to tool for any kind of learning and quick resource. I often use GeneReviews and OMIM… to learn more about a genetic condition or to

> understand more about a gene specifically. And then, if I want to get some into the primary literature, then I'll do a PubMed search. (Betsy)

These interviewees first framed an overarching understanding of the topic by visiting websites with easily accessible summary documents: GeneReviews, UpToDate, and OMIM (Online Mendelian Inheritance in Man). Once the landscape was sketched, they filled in detailed points with reference to Google Scholar or PubMed – powerful search engines abetting retrieval of primary, empiric data.

Lectures/presentations. Reading and researching provided formalized written information; the auditory equivalent was attending lectures and presentations. Respondents encountered these learning opportunities at national conferences, within their institutions, and online through webinars. One respondent explained the strength of lectures: "Going to talks about the technology was especially beneficial, it helped me to better understand the limitations of the testing" (CIQ 37).

Genetic counselors clearly prized formalized information in articles and presentations as means of acquiring the knowledge necessary to assess and incorporate new tests. Through reading, researching, and listening, they learned test methodologies, potential and appropriate applications, and limitations. Respondents implied these were solitary learning strategies, in contrast to formalized learning in social situations such as national conference.

There was a sense that respondents sought to match the extent (and perhaps pace) of their learning to the perceived deluge of information to be learned. Several statements intimated at voracious consumption of learning to the point of exhausted stores: "every online resource I could find - industry, academic, collegial" (CIQ 78), "read every entry on the listserv" (CIQ 104), "went to every talk I could regarding cfDNA screening when I was able to attend conferences" (CIQ 19), "use as many resources as I can find through NSGC, including webinars" (CIQ 321). In the effort to be thorough, genetic counselors procured learning resources from a variety of sources. The National Society of Genetic Counselors was noted to be a font of useful tools: "turning to NSGC for up-to-date information and resources for practicing genetic counselors has been the most helpful for me" (CIQ 315). Similarly, testing laboratories "were helpful in attempting to arm GCs with tools to use in their practice" (CIQ 29) in the forms of information on testing technology (CIQ 233) or pictures or diagrams used in explanations to patients (CIQ 230).

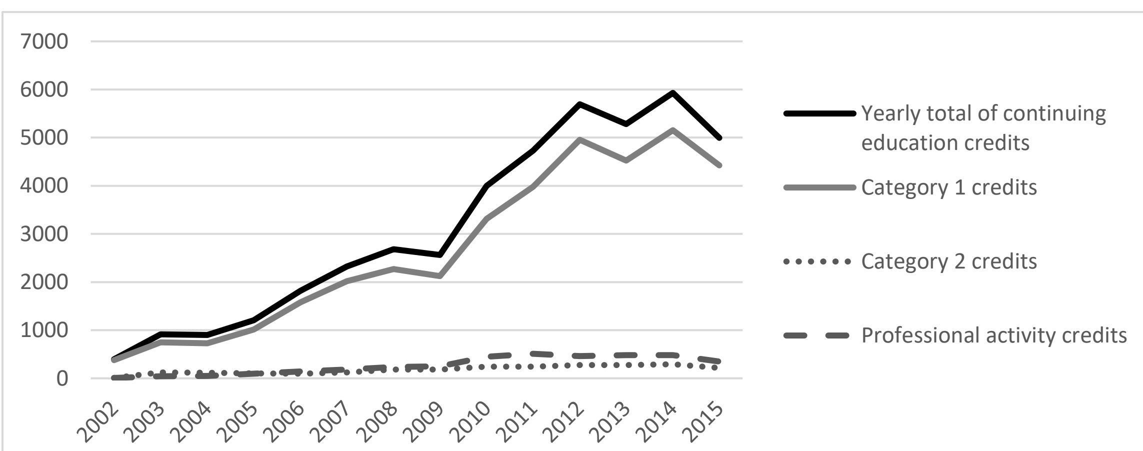
Continuing education units. When examining formalized learning strategies, several interviewees addressed the influence of CEUs on their impressions of professional learning. One interviewee stated of messaging that "a very tactile one is the CEUs and having to keep up with your certification and sort of forces you whether you want to or not" (Louisa). CEUs were referenced as an official, formalized layer within professional learning:

> I think the NSGC and the ACMG have all been very clear, that needing to stay awake or alert to changes in the field, to getting your CEUs. They've been very clear that that's valuable and I think their need for it has been clear also in requiring CEUs." (Elinor)

Many viewed the compulsory nature of CEUs as proof of the necessity of professional learning, as carried out through enforcement of regulations surrounding it. To clarify the positionality of continuing education unit credits as formal, structured, explicit professional learning by genetic counselors, a database of CEU credits was analyzed.

The database included deidentified entries of credits accrued and submitted online for the purposes of recertification through the American Board of Genetic Counseling. Analysis of professional learning activities submitted as credits toward recertification was incorporated to provide an extended profile of formal, structured, explicit professional learning of genetic counselors as defined, approved, and codified by the credentialing body. Additionally, assessing the collective response of genetic counselors to requirements for minimum and maximum number of credits from particular categories – in the form of submitted activities – was explored to shed light on the profession's preferences for different professional learning strategies. Comparison and contrast between requirements and actual submitted activities highlighted how the profession's members and credentialing body understand, and perhaps constrain, professional learning.

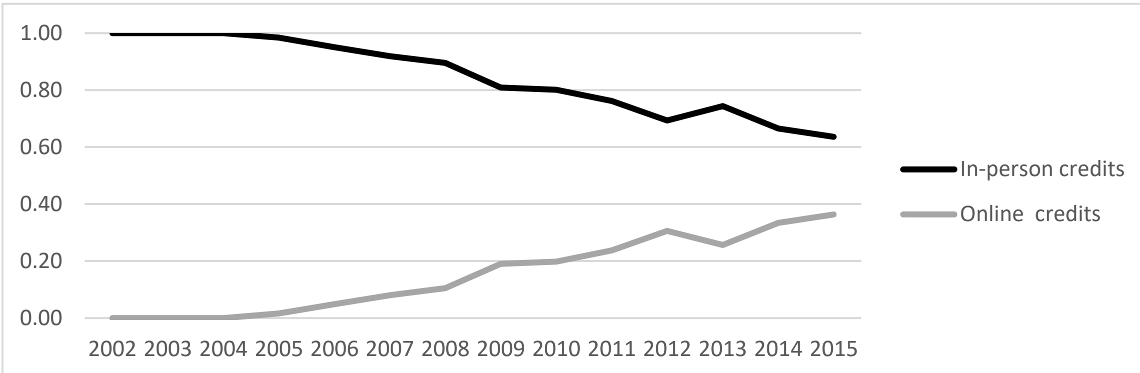
All activities included submitted for credit and included in the analysis occurred in the years 2002 to 2015. The majority of entries and total credits were category 1 credits (educational activities directly related to genetics or genetic counseling), followed by category 2 credits (educational activities approved for continuing medical education in other healthcare professions), and professional activity credits (activities or service for genetics-related organizations). Graph 1 highlights the rapid growth in continuing education activities in this time frame, primarily due to the growth of category 1 credits.



Graph 1. Growth of continuing education unit (CEU) credits, 2002-2015.

Category 1 credits. This category included 34629 unique entries and 37202.47 total credits (86% of all credits). It was important to note that continuing education requirements for recertification through the American Board of Genetic Counseling stipulate that at least 60% of the credit requirement be met with category 1 credits. Chi-square analysis of total category 1 credits compared to expected total if category 1 credits constituted exactly 60% of the credit total showed that the total is significantly different (elevated) above the minimum required, suggesting a strong preference exists for this type of credit, though sources of this preference could not be determined. Category 1 credits were mostly earned by attendance at in-person educational activities such as national conferences of the National Society of Genetic Counselors (NSGC), American College of Medical Genetics (ACMG), and the American Society of Human Genetics (ASHG) (see Appendix N for a list of the top twelve providers of category 1 credits). Genetic counselors also demonstrated engagement with the literature (further corroborating reading as a preferred learning strategy) through a remote journal-club-style reading program in which credits (initially category 2 but transitioned to category 1 in 2006) were earned by reading specified articles in the Journal of Genetic Counseling and passing a quiz on the reading.

Online educational offerings began with online courses offered by the University of Cincinnati (the first an online course in embryology first offered for credit in 2005) and a boards review course offered by the University of Pittsburgh. Online educational opportunities demonstrated steady growth in credit total and diversified offerings in the form of conference recordings, online courses, and webinars thereafter. NSGC began posting recordings of past conferences as online education opportunities in 2008, and the following year commenced with developing content specific to online courses. By 2015, in-person and online activities had reached relative proportions of 64% and 36% of total credits, respectively (see Graph 2).



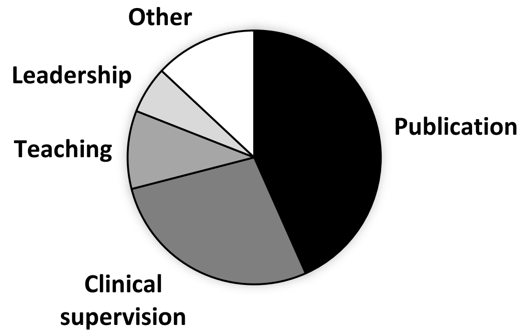
Graph 2. Relative proportions of category 1 credits conducted in-person and online.

Online educational activities were entered either as a single completed course or as individual lectures within a course, indicating that genetic counselors completed online courses or viewed conference recordings incrementally.

Category 2 credits. This category included 2442 unique entries accounting for 2486.13 total credits; yearly totals of category 2 credits remained relatively constant over the 14 years included in the analysis (see Graph 1). ABGC's continuing education requirements stipulated that no more than 40% of continuing education credits could be category 2 credits. Chi-square analysis of total category 2 credits compared to expected total if category 2 credits constituted exactly 40% of the credit total showed that the total is significantly different (decreased) below the maximum allowed, suggesting a strong disinclination for this category, though sources of skew could not be determined.

Of the three categories of continuing education units, category 2 credits were the most wide-ranging in terms of sponsoring organization and topical area. This was unsurprising considering that category 2 credits are inclusive of educational activities from related healthcare professions so long as they were previously approved for some type of continuing medical education (CME) credit by an accredited body. The entries in this category were not amenable to deep analysis given the broad spectrum of included activities and somewhat ambiguous descriptions provided to identify the activities.

Professional activity credits. This category included 6060 unique entries accounting for 3737.88 total credits. Professional activity credits (PACs), similar to category 2 credits, represented a small fraction of total credits and remained relatively constant during the time frame studied (see Graph 1). Continuing education requirements stipulated that no more than 20% of total credit requirements could be met with professional activity credits. Chi-square analysis of total professional activity credits compared to expected total if professional activity credits constituted exactly 20% of the credit total showed that the total is significantly different (decreased) below the maximum allowed, suggesting a strong disinclination for this credit type, similar to aversion to category 2 credits. PACs are earned by engagement with the profession or community on topics of genetics or genetic counseling. Publication, clinical supervision, and teaching – three key modes of participation in the profession – represented the top three PAC activities based on total credits accrued. Leadership activities to a genetics-related organization was somewhat common, followed by a variety of other activities including volunteer service to genetics-related organization, presentation to professionals, genetics education outreach, undergraduate or graduate coursework, peer review of manuscripts, patient education publications, non-peer reviewed publications, volunteer at a chronic disease specialty camp, and peer supervision groups (see Graph 3).



Graph 3. Types of professional activity credits. “Other” includes volunteer service to genetics-related organization, presentation to professionals, genetics education outreach, undergraduate or graduate coursework, peer review of manuscripts, patient education publications, non-peer reviewed publications, volunteer at a chronic disease specialty camp, and peer supervision groups.

Analysis of formalized, explicit professional learning activities in the database of continuing education units showed that actual proportions of category 1, category 2, and professional activity credits were significantly different than the maximum and minimum levels of the requirements. There appeared to be a strong skew in favor of category 1 credits and a proportionate decrease in utilization of category 2 and professional activity credits. Sources of differential utilization of credit types could not be determined given all entries were deidentified and collectivized.

Informal, intuitive, implicit learning strategies and resources. Though not as readily identified as formal learning strategies, informal strategies were mentioned in association with intuitive, implicit learning often arising from and remaining connected to practice. Such strategies included reflection and critical thinking and experimentation on one’s own, and discussion and dialogue with colleagues.

Reflection/critical thinking. When assessing one’s knowledge base in preparation for a case, seeking alternative perspectives or experiences to buttress one’s approach, or sifting through data and information, genetic counselors found themselves employing reflection and critical thinking. Interviewees described reflection and critical thinking as independent, internal thought processes. Darcy correlated critical thinking with a character trait: "I consider myself pretty self-sufficient and so I think it is, sometimes it's just as easy to try and figure it out myself" (Darcy). He situated critical thinking as an example in which personal traits extended to professional behaviors.

Mariah presented reflection as a tool or instrument which she used to make sense of the continuous flow of incoming experiences and outgoing actions:

> I do close introspection. Then I think that whenever I get out of a meeting or call, it's my tendency to be like, "OK, what do I need to do to follow up on this?" Because things can escape me if I don't take care of them right away. I make it a point to close out or review any follow-ups that need to be done from the day's meeting that day. Then on my way home, I'm thinking back to some of the things that were said, and sometimes when I replay some of the conversations in my mind, I then end up being like, "Oh, that's what this person meant. I didn't gather that right away when we were at the call". (Mariah)

Independent reflection enabled her to recast her interpretations of her work experiences daily, and resulting insights informed her actions for the following day.

Lizzie described critical thinking as a constructive process of amalgamation and animation: "let me start to now apply these pieces of information and these tools that I've now learned about, let me try and make the machine work, and then compare the output with what someone else got" (Lizzie). She combined new learnings, put them to work through application, then analyzed her findings by comparing and contrasting them with the conclusions of others with the intention of applying it to future, similar scenarios.

These three interviewees spoke directly to processes of reflection and critical thinking, as a manifestation of a character trait, instrument for guiding action, and process for synthesizing and applying other learnings, respectively. Though identified as a learning strategy, descriptions of this approach were limited, perhaps in keeping with the implicit function of these thought processes during a typical work day.

Experimentation. Similar to reflection and critical thinking, experimentation was endorsed by only a handful of participants, who described this strategy in two distinct ways. First, experimentation was defined by respondents to the critical incident questionnaire as a form of trial and error: "just jumping in and learning by making mistakes" (CIQ 38). This meant incorporating an innovation directly into practice and subsequently refining the approach through successive, iterative attempts based on perceived success or failure: "for me, the most important step was to continue to offer multi-gene panels to patients and alter my panel explanation as I became more comfortable explaining this level of testing to patients" (CIQ 16). Preparation prior to incorporation seemed irrelevant when the learning process was "completely experiential – I tried different approaches to organizing my sessions and my prep/follow-up" (CIQ 105). Experimentation as an informal learning strategy found participants prioritizing practical application followed by reflection and adjustment, in a reversal of formal information-gathering by reading or attending lectures to establish a knowledge base to be applied subsequently.

A second angle of experimentation grew from creating artifacts to solidify, condense, or anchor the learning. One respondent "attempt[ed] to create new personal policies as a way to create a framework to control a chaotic first few months, including what labs and tests to offer to which patients" (CIQ 38); creating an individualized artifact to document discrete points of learning brought order to the chaos introduced by a new technology. Another respondent found that "writing sample dictation paragraphs describing the new testing allowed me to solidify a simple accurate explanation" (CIQ 40).

Experimenting with written descriptions of the technology operated as a testing ground for clarifying one's own understanding and finding the language to relay that understanding to others, and possibly cemented conclusions from ongoing reflection.

Discussion and dialogue. While reflection, critical thinking, and experimentation were enacted independently and by a small number of participants, discussion and dialogue were unquestionably the primary means employed by genetic counselors for professional learning in response to innovation. These informal interactions with colleagues were denoted by words such as "discuss," "talk," "consult," and "ask." Given the prominence of this theme throughout the dataset, the following quote seemed most illustrative: "Colleagues! We experienced these changes together - therefore we learned and adjusted our styles as a team, although profoundly different individual personalities. Research and talking, talking, talking to one another was always the most helpful" (CIQ 45). Genetic counseling is a helping profession, an educational and counseling service founded on a working relationship between patient and provider; it was therefore viewed as appropriate and fitting that the main learning strategy of genetic counselors involved an essentially relational activity – discussion with colleagues.

The communicative nature of genetic counseling practice was reflected in the emphasis on discussion as a strategy for learning: "I would say that for me, discussion and dialogue [are] definitely the most important aspect[s]" (Lizzie). Indeed, "just bouncing ideas off and sitting down and having conversations with other people with different experiences and a different knowledge base than me" (Marianne) was consistently reiterated as the main mechanism of engaging with others for the purposes of professional learning. So vehement was the desire for discussion that interviewees sought colleagues from multiple sources:

> I'll discuss with coworkers in the office the case, see if they have any thoughts and then if necessary, speak to more broad genetics colleagues, so whether that is a lab genetic counselor, coordinator, whether that is the National Society of Genetic Counseling listserv, or someone who I know tends to be knowledgeable on a particular area. (Caroline)

Whether near or far, in person or online, genetic counselors found other genetic counselors with whom to converse and learn as they pursued perspectives: "I still gain a lot from looking at the literature, but it leads to so many more questions and sometimes I just get better perspective about it from talking to people" (Kitty). Interviewees saw discussion as a way to obtain perspectives from others and take perspective on their own understandings.

Reflection, critical thinking, experimentation, and discussion and dialogue constituted informal learning strategies used by genetic counselors frequently, though there was evidence to suggest the ubiquity of these strategies was challenged by the implicit nature of learning through routinized behaviors.

Challenges

Participants named numerous formal and informal strategies, suggesting a formidable collection of approaches to professional learning. Yet they also recognized their learning was challenged by barriers to effecting these strategies, most notably that of time. "Far and away, it comes down to time…. time in the day" (Susan). Interviewees conceded that time was the primary factor limiting professional learning, not simply because there wasn't enough of it, be rather because of the mass of other commitments constantly competing for attention.

> Trying to deal with day-to-day learning between clinical and administrative responsibilities, I feel like I'm just shoving it in. And I'm not spending the time to really ponder and look at it. And when I do, I feel guilty for doing so because I'm not doing something else that needs to get done. (Caroline)

Caroline traced the perceived lack of time to the heavy workload of many genetic counselors. In circumstances of high demand, time and effort were funneled to meet the needs of the clinic, depleting the time-related resources necessary for focused professional learning and depriving one of desired focus for reflection. She also pointed out an internal motivation to do quality work and quality learning. Within demanding circumstances of competing responsibilities, prioritization was a necessity. Darcy noted prioritization in conjunction with quality considerations:

> Making sure that you are getting better and developing at the job that you have, I think, is even less of a focus many times, because of the limited resources available to genetic counselors and genetics departments… It's more like, "See these patients" not like, "I think we really could have done a better job with all that." (Darcy)

Darcy reasoned that genetic counselors have challenging workloads due to limited staffing; in a low-resourced environment, patient care is emphasized for revenue purposes, leaving little time or funding for professional learning. The focus is on maintaining current procedures rather than seeking improvement.

When time was invoked as a challenge to professional learning, interviewees noted internal (wanting to fulfill work-related responsibilities, be able to devote full attention to learning) and external (pressure to focus on patient care) commitments competing for their attention. Regardless of the source of competition, professional learning was sidelined in favor of focus on the work.

Alternatives

To ascertain the strength of preferences held by participants for their learning strategies, interviewees were prompted to contemplate alternatives if their primary strategies were for some reason unavailable. Nearly all paused or asked for clarification of the question, and most eventually replied with a crafty means of avoiding the proposed deprivation.

> It's tough to imagine that, you know, like I think I would do everything I could, and I guess that's biased because I know how valuable it is and how helpful it is, so if I never knew that, what I would do… I can't imagine me not going and finding people and asking them questions. (Fanny)

Several invoked humor and hyperbolic imagery: "I'm picturing myself in the middle of nowhere with no computer and no colleagues to talk to…" (Lucy); "Have a meltdown" (Georgiana); "My life would be over" (Marianne). As would be expected, the potential loss of dearly held, functional strategies was met with consternation: "That does give me a little bit of anxiety because I don't feel… I would not feel comfortable…" (Lizzie). Anxiety quickly gave way to clever problem-solving: "I still think that it would be my two standard methods, I would just do it in a different way" (Marianne). If preferred colleagues were not available, they turned to someone else: "I would need to reach out to somebody… I don't think that I could be a decent genetic counselor without having access to some kind of a resource outside of just my own knowledge…" (Georgiana). If online databases or current literature was inaccessible, they turned to books: "If my typical approach of looking in journal articles… if the internet was down, I would totally just go old school and go to the library" (Marianne). Several commented on the disquiet such speculation induced and their reluctance to propose alternatives, eventually reframing their reactions as evidence of the strength and efficacy of their current learning strategies and resources.

Advice

After ruminating on their professional learning preferences, challenges, and alternatives to their current learning strategies, participants approached these concepts from an alternative perspective by instead considering how others could best enact professional learning. They proffered the following advice for fellow genetic counselors: anything can be a learning opportunity, go beyond the boundaries of the profession and learn from other disciplines, think carefully and continuously about the work, build a bevy of colleagues, and make the effort or find the time to learn because patients depend on us to do so.

Cast a wide net. Interviewees believed there was always more to learn and assumed an inclusive orientation to learning. They suggested latching on to any and all learning opportunities as they arise, regardless of whether it presents as a learning opportunity, encouraging genetic counselors “to never assume that any opportunity isn’t a learning experience; to never assume that you’re the smartest person in the room, unless you truly are the smartest person in the room or it’s a very limited room” (Elinor). Instead of seeking learning as a separate and distinct activity, interviewees invited genetic counselors to assume learning is embedded in all other activities. This mantra applied to practice and each patient encounter:

> Some people may not realize that they are constantly learning even if it’s not an active thing. Especially from a clinical perspective, I think any time you get a new patient in, every patient’s going to be different and so there’s something that you can take away from that. And so I guess my piece of advice is to keep your mind open to educational opportunities that may not look like educational opportunities. (Marianne)

These interviewees reminded genetic counselors of their responsibility to engage in ongoing learning and concurrently intimated the task was manageable given the abundance of opportunities when using an expansive definition for what constitutes learning.

Several interviewees specified that the notion of finding learning opportunities everywhere could be potently applied to learning from other specialties and professions. In some sense working as a different framing of “cast a wide net”, these interviewees encouraged genetic counselors to “escape the bubble” – rather than embrace learning that doesn’t appear to be learning, the exhortation was to actively seek activities in other disciplines. Speaking of other genetic counselors, one interviewee stated:

> I think it’s really important for them to go to other specialties’ meetings or grand rounds or conference when they can and not just live in this little bubble of genetics only, because there’s so much that goes into it… It can be reciprocal learning, back-and-forth between genetics and other specialties. (Charlotte)

Escaping the genetics bubble introduces genetic counselors to the reciprocal learning that can occur among different specialties in medicine. Bubble bursting was further encouraged as another interviewee reminded genetic counselors to look beyond medical specialties to other fields and professions:

> Taking those moments to make certain you’re also reading a business journal, so you can get the bigger picture that’s not just genetics, reading things for the lay population, getting that bigger picture and not staying so in the weeds to try to stay current. (Henrietta)

Henrietta accepted that staying current was a daunting task and could absorb all available time for learning as a genetic counselor attempts to keep pace with updates in her scope of practice. However, she cautioned against the narrowing, pigeon-holed perspective this strategy could yield, instead urging genetic counselors to read broadly to nurture an encompassing, high-level perspective.

Reflective practice. *"*Cast a wide net" and "escape the bubble" were bits of advice that asked genetic counselors to look outward – far and wide, in fact – in service to professional learning. Others encouraged the reverse, to turn inward and fortify a reflective practice, "to not rely on any assumptions that you already have, to be sure to kind of examine your own thought process really carefully" (Lizzie). Reflective practice was supported for its usefulness in handling minute judgments as well as facilitation of an overarching grasp of all one's experiences:

> When you have the opportunity and your job allows and your family life allows, that you do take that step back and really try to think about what the bigger picture is in our careers, in the world. That would actually help you be stronger in what your next step should be specific to your specialty. (Henrietta)

Reflective practice was noted to provide clarity along the spectrum of micro- to macro- level thinking, and through that clarity, to aide decision-making. Active application of reflection was underscored by Anne, who felt action was a necessary component of reflective practice:

> From my perspective, it's take a very broad approach to what you mean by learning, reflective about all of your experiences, it doesn't mean just about what you're doing in clinic, but it's "what have I learned from this internal review board meeting?" and making a plan for, "OK, how are you going to use that, what I've learned?" So, broaden your view of what learning is and incorporate that into having a reflective practice and then the next part of that is make sure you think about follow-up with what you've learned. (Anne)

For this interviewee, casting a wide net and reflective practice were complementary learning strategies culminating in a plan for next steps, which were actions that put the learning produced by reflection to work.

Cultivate a formal network. Interviewees incorporated their love of colleagues into the advice they gave by extolling the virtues of building a formal network:

> Having relationships with other people, because obviously it's important if you're seeing something to read the more recent article and make sure you're kept up with the literature on it. But if you have people, sometimes I think they can tell you more specific things or give you a perspective that you might not pick up on from reading a review article… Tell your colleagues, "I don't know what to do with this result, do you know anyone who knows about this kind of thing?" Because all of your GC friends have other GC friends they can try to connect you with. And people are always really responsive. So, I think, not isolating yourself. Even if you are really up on the literature, you still can't isolate yourself. (Kitty)

Kitty accentuated the unique, integral contributions which others make to professional learning - providing insights and alternative perspectives as well as sharing resources. She also painted a portrait of wider networks of genetic counselors in the profession at large, suggesting that colleagues would either personally provide assistance or make connections with those who could help. Kitty promoted these networks as invaluable and irreplaceable by independent study.

Take initiative and advantage. Interviewees acknowledged responsibility for professional learning and directed genetic counselors to take advantage of factors which make professional learning feasible, such as working in a team or protected time for professional development.

> You do have to put in that effort, you do have to make that time, and so the most important thing that I can say is, work that out amongst the genetic counselors that you work with or with your manager or your supervisor and find ways to convince them how important it is for you to have continued learning. It doesn't have to be expensive, it can be webinars, "can I just block my schedule for an hour, so I can listen to this webinar or an hour to go to grand rounds?" We tend to get so focused on patient care and we don't really have to get tons of continuing education credits as genetic counselors… So, it just seems like we really need to take advantage of that as much as we can. (Charlotte)

Charlotte argued that the means for professional learning could be procured, but ownership and initiative had to be taken. Lucy agreed and connected the need to take initiative with the responsibility to provide quality patient care.

> Just taking the initiative yourself. I think it can be so easy to be complacent and not taking that extra step. I have a tendency to want to know as much as possible and that drive to continue to learn and not be complacent in what you already know, especially in a field like this where it's changing all the time. You have to take that initiative – almost more for the due diligence of your patients in making sure that you are getting them all the right information and not missing something that, it may not seem like a big deal, but it could have serious implications down the road, or impactful ones at least." (Lucy)

These interviewees allowed that professional learning required extra efforts – cordoning off time in a busy schedule, finding resources or events. Nevertheless, they insisted professionals had a duty to pursue professional learning, including to take initiative and take advantage of factors enabling that learning.

Interviewees' advice positioned genetic counselors to actively survey for professional learning opportunities, taking initiative and advantage as much and whenever possible. They were encouraged to involve others and think creatively about perspectives incorporated into their own, especially those found beyond the boundaries of the profession.

Overall, genetic counselors employed many strategies – formal, structured, explicit as well as informal, intuitive, and implicit – for professional learning, much of this to further incorporation of innovation into practice. These divergent strategies in some ways mirrored the disparate aspects of professional practice: counseling and science. Genetic counseling is centered on assisting others during a process of absorbing information needed to make an informed decision and requires close interaction with others; hence, it made sense that genetic counselors centered their professional learning on interaction with others through discussion and dialogue. Yet it is complex information that must be relayed; therefore, it was logical that respondents highly valued formalized information acquired through reading or attending structured activities that gave rise to the professional knowledge which was then translated to explanations accessible to patients. And as technology and testing is constantly changing, genetic counselors needed to become accustomed to trying new things in practice, concurrently and systematically assessing the effects of innovative approaches, as evidenced through the strategies of experimentation, reflection and critical thinking. When conscientiously utilized, these learning strategies yielded ongoing adjustment and change, new practices, and new perspectives which they encouraged in other genetic counselors by sharing advice derived from their firsthand experiences of professional learning.

What Roles Do Colleagues Play in the Professional Learning of Genetic Counselors?

Genetic counselors extolled the value of colleagues as partners in their learning and explained the methods by which they interacted and collaborated. Interactivity was foremost among facilitators of the learning process, especially as enacted through discussion and dialogue. Participants expounded on the intents and purposes of interacting with colleagues – to swap professional opinions and interpretations, pool experiences, and gather feedback on one's personal approach. They also attended to considerations when choosing others as partners in interactive professional learning, including those of other disciplines who were seen as enhancing and extending learning with others by virtue of espousing alternative perspectives.

Interactivity

Comments on discussion, swapping opinions, pooling experiences, and feedback were connected to a broad theme of interactivity – the potency of engaging with others to further learning. They were particularly emphatic about in-person interactions:

> Going to a conference is great, there's sort of an atmosphere of excitement and learning that you get when you're there in person. And I think there's no substitute for that face-to-face learning experience as well as the discussions that happen among other people who are attending. (Betsy)

Conferences were noted to offer ideal circumstances for interactivity by creating a space that brings people together during protected time away from the daily routine. Others benefited from interactivity in their regular work: "We have a pretty darn interactive team, so most of the time, when I have a specific question or I'm aware that I need to learn something, I go ask a person typically rather than look in the literature" (Margarette). Interviewees were strongly drawn to interactions with others, for specific aims of professional learning as well as inherent enjoyment.

Collaboration

Nearly all respondents to the critical incident questionnaire mentioned turning to others, seeking to engage in interactivity by way of collaboration – working together for shared learning. In doing so, they made learning partners of colleagues, coworkers, peers, and friends of various professions – genetic counselors, physicians, testing laboratory personnel, and others. Collaborations were conducted with participants' immediate work group, in their local professional communities, and nationally at conferences. They collaborated to swap professional opinions and pool experiences.

Swapping professional opinions. Collaborations were frequently initiated to swap professional opinions about available information or effective approaches to the work; this was described as an opportunity to vocalize individual opinions and compare and contrast those opinions with others' interpretations. In many cases of interpreting new information, collaboration occurred through informal interactions among members of a working group as they had “many internal discussions to review the collective info” (CIQ 91). Group members exchanged information and interpretations of available resources to nurture the shared understanding underlying uniform standards of practice:

> I also discuss current statements/policies from insurance companies, NCCN [National Comprehensive Cancer Network], ASCO[American Society of Clinical Oncology], NSGC [National Society of Genetic Counselors], ACMG [American College of Medical Genetics], etc. with other genetic counselors and providers at my institutions to promote consistency among testing and management strategies. (CIQ 321)

Sharing and comparing information and interpretations of that information assisted genetic counselors in developing and refining understandings, opinions, approaches and safeguarding against the ambiguity of working in isolation.

Many respondents availed themselves of opportunities designed to foster collaboration, such as journal clubs to collectively assess new literature, or case conferences to analyze challenging patient presentations or scenarios:

> I'd say that participation/coordination of the journal club on NGS technologies in our otherwise clinical group was very helpful and prompted myself and my colleagues not only to educate ourselves on technology, but to start thinking about the impact on our practice and the overall likely changes coming to the genomic medicine. (CIQ 58)

This form of collaboration facilitated the incorporation of innovative technologies by generating shared knowledge and, by comparing and contrasting perspectives with colleagues, building original approaches to utilizing the innovation in practice.

While respondents emphasized the importance of coworkers as learning partners, they also mentioned collaborating with physicians and testing laboratory personnel. When interpreting an ambiguous result, a genetic counselor would reach out to others as a means of “seeking out additional clinical information from the ordering physician” (CIQ 43), gathering their alternative perspective and professional opinion to more effectively utilize case-related information for individualized care. Genetic counselors also described the support of interfacing with testing laboratory personnel when learning about new testing options: “liaising with lab reps and GCS in laboratory positions helped a lot in gaining an understanding of panel testing and the genes involved” (CIQ 29). Testing laboratory personnel were seen as accessible, informative, helpful learning partners as they provided resources, knowledge, and insight into the testing methodologies.

The professional opinions traded through collaboration with others centered on interpreting new information or in formulating effective approaches to using innovative technologies in one’s work. As an extension of information and knowledge related to innovations, genetic counselors collaborated to devise approaches – philosophies or skills of application – to utilizing innovations in their work. A genetic counselor stated this as follows: “I am also fortunate to work with other genetic counselors and medical geneticists who were experiencing a practice change. We had many group discussions about our philosophies on these tests and how to utilize them” (CIQ 68). Respondents seemed particularly interested in collaborating on skills for explaining testing to patients to facilitate decision-making: “I incorporated ways in which my colleagues were able to explain the changes to their patients, so I utilized their techniques and then molded them to something natural for me” (CIQ 80). Approaches were shared, modeled, adapted, and personalized with the help of their colleagues.

Pooling experiences. In addition to swapping professional opinions, respondents to the critical incident questionnaire collaborated by pooling their clinical and learning experiences and efforts. Whereas swapping opinions was a tactic for interpreting new information or strategizing novel approaches, pooling experiences was distinguished by collaborations focused on intermingling past clinical encounters, creating a collective repertoire from which to derive new impressions or ideas. Rather than working as a double-check on one's personal interpretation as swapping opinions did, pooling experiences allowed a genetic counselor to absorb experiences of others to use as one's own, as a way of filling a gap through networked experiences. For instance, one respondent offered that through discussion with colleagues, she "was able to learn from their experiences and gain information that I had not considered/come across while doing my own searching" (CIQ 256). Others' clinical experiences were absorbed as one's own.

Genetic counselors outlined how experiences were pooled: "Things change overnight and sometimes you can't always keep up. That's where other genetic counselors come in. Maybe they've had time to read the latest article or they went to that conference you missed" (CIQ 57). Pooling experiences was perceived as a way to expand one's capacity for professional learning. In one example, time, energy, and workload were pooled to accomplish a collective learning goal: "We divided up the list of new genes, individually performed literature searches, and then met as a group to present a summary of our research" (CIQ 84). This provided an ingenious response to the overwhelming complexity which innovative technologies introduced by bringing more choice, greater scope, and increased uncertainty to the clinic.

Interviewees also relied on pooling experiences with others. They described this strategy as involving focused discussions about past, relevant experiences such that one might absorb the experience of another as one's own, in some ways collectivizing the individual experiences:

> An example would be being exposed to other genetic syndromes or things that maybe I haven't come across myself, but being as that there's five of us here, we're

> able to see a wider breadth of things which is keeping myself up-to-date on the screening recommendations or things of these more rare syndromes that my colleagues may have seen that I haven't yet. (Lydia)

Several interviewees intimated at the inherent limitation of a single person setting out to master the full spectrum of practice, and described how they attempted to bolster one's limited scope by pooling experiences:

> If there's informational stuff out there, any of us can look that up, but that's not the same as having had the experience of giving this particular drug to somebody and it had this effect. I think having those personal experiences with previous patients is a huge thing. And to me, you know I changed careers, so for me, that was the biggest thing I felt missing in my new career and the loss of in my old career was that accumulated experience that informs what you're doing now. (Jane)

Pooling not only magnified the breadth of experience owned by an individual, it quickly supplemented a perceived deficit related to a young career. The notion of expedience was also invoked by an interviewee who, rather than dwelling on the present state of incomplete information, used pooling to anticipate a point in the future when the necessary information would be available.

> Getting published data can sometimes take a while, getting robust enough Ns and those type of things, so just hearing about people's experiences… I'm just looking for overall experiences and what people are finding that they're doing and if they're finding something useful or not useful. (Louisa)

For both Jane and Louisa, pooling experiences from colleagues allowed them to efficiently gain the knowledge and perspectives they felt they needed to be competent practitioners, to expand their personal stores of examples from which to draw when acting in a novel, uncertain, or ambiguous practice situation.

National conferences. On a grand scale, respondents attended conferences as a means of pooling experiences. One respondent described a sense of responsibility to contribute to the pool by relaying her experiences at conference: "I was the only one from our clinic who was able to go to the NSGC meeting both years, so bringing back the information and discussing with other GCs was crucial" (CIQ 91). In this case, the genetic counselor served as a conduit for information. Another respondent wrote about attending conference and absorbing the collective experience:

> Attending the NSGC AEC was helpful in that it addressed many of the questions being asked at my institution. The success stories presented in overcoming some of these practice challenges provided insight into bringing these solutions to my practice while discussion of lingering challenges at least validated my feelings of insecurity/doubt due to lack of established guidelines. (CIQ 321)

Indeed, collaboration at the national level allowed genetic counselors to amass a pool of a greater number of experiences from which to garner insight when incorporating innovations. Collaborations on this scale were carried out mainly through attending conference, but also through participation in the professional society's special interest groups via listservs and online discussion forums. From the above quote and quote below, it was evident that collaboration yields validation:

> Honestly, the Cancer SIG listserv was a lifesaver (and still is). It's great to see that I'm not the only one struggling with some of these new innovations and is a wonderful place to bounce ideas off other GCs around the country. (CIQ 57)

Pooling experiences with genetic counselors in the same specialty through dialogue in person or remotely was a highly valued strategy for professional learning among respondents.

Feedback/validation. Swapping professional opinions and pooling experiences took as the object of inspection objective topics. These outward-facing strategies socialized professional learning by involving others, and flow of insight was external to internal, others to individual. In the same vein, participants welcomed feedback as a strategy for examining and enhancing their professional competence. Feedback – though outward-facing and inviting others' input – had as its target the individual's internal, subjective judgment rather than an external, objective point of data or case scenario. In this way, feedback was more personalized than discussion and pooling.

Interviewees sought both critical and validating feedback. Fanny was particularly adamant about the importance of critical feedback for fostering her professional (and perhaps personal) development:

> Honestly, the first thing that comes to mind is I want to learn where my weaknesses are and what I'm doing wrong. I'll always ask that question, 'What am I doing wrong?' or 'What could I have done better?' because that's something where I find most people you interact with won't give you that kind of feedback but it's really what makes you successful. You have to know those things and it's not always easy to see in yourself… I want them to push me to be better as I'm trying to learn more. I know that I'm naturally curious, so I'm going keep asking them questions and things, but I want to make sure I'm on the right track… I guess I'm hoping to gain is just that critical evaluation of myself. (Fanny)

She recognized the boundaries of analyses she conducted herself and valued the promise of additional capabilities and growth she could achieve through others' feedback. While Fanny highlighted the impact of feedback on both behaviors and an overarching sense of self, Georgiana applied critical feedback to her judgment:

> There will be a lot of times where I feel like I have a thought about what I think needs to be done, but I'm not entirely sure if I'm missing something from a different perspective, so I will often go to the other physicians, whoever I'm working with that day to make sure that I'm thinking about it appropriately. (Georgiana)

Georgiana described her thought process to her colleagues and asked others to inform her of errors or omissions in her approach. Her intent was to use feedback to strengthen her thinking.

Developing new capabilities and strengthening professional judgment were goals for applying feedback toward extensions of one's current capabilities. Caroline countered this by offering an example of using feedback to maintain a functional baseline, and instead of cognitive or behavioral features, illustrated the emotional importance of feedback as validation:

> When you're presented with a challenging case or as a genetic counselor you've had a rough week or things are just not going so well in your work day or just in your day, period, having someone say, "You're doing a good job" is almost how I look at that validation. So "you're doing what you can, you're on the right track, you're giving good care, you have a plan for good care" – and that is a confidence booster. (Caroline)

Behavior, judgment, and emotional wellbeing were all named as objects of others' feedback, with critical and validating feedback both serving as professional learning strategies for genetic counselors in need of insight.

Colleagues as Learning Partners

Participants strongly emphasized the role of colleagues in their professional learning. Interviewees spoke eloquently and at length about the contributions colleagues made to their professional learning as they sought and received expertise and alternate perspectives from a variety of learning partners. "I think colleague support is probably my number one resource and I'm very much a fan of find the best person in that area and like pick their brain and learn that way." (Fanny)

Considerations for choice of learning partners. How did interviewees identify who this "best person" might be, the preferred learning partner? They frequently named expertise as a ready indicator.

> When I'm reaching out to colleagues, I'm usually reaching out to them based upon their expertise, and so I'm hoping to gain from their expertise. And when they reach out to me, they're hoping to learn from my expertise. And so, you know, when I reach out to the researcher, I'm expecting them to be familiar with all the different aspects of it. When I reach out to my curation team, I'm expecting them to bring in a level of judgment and perspective that I don't have. And so, it's not a random reaching out to colleagues at that level, it's a directed reach out to colleagues who I feel have the appropriate expertise and experience to guide me further. And then

> having spoken with them and reached some kind of consensus or conclusion about what's next, then I would take that information and go lateral and down or up if needed as far as dispersing and implementing it. (Elinor)

Elinor saw individuals as having unique perspectives and interpretations which could be tapped to direct subsequent efforts of learning and application. For her, expertise – as cultivated judgment, defined perspective, and specific experiences – was the primary consideration when choosing whom to approach for insight and suggestions. Betsy suggested someone's role or title served as an easy proxy for ascertaining others' area of expertise:

> Moving from a clinical role into a lab role, I felt like there are a lot of things I didactically needed to learn or needed to understand on a deeper level…. molecular mechanisms and how testing works, and so I have asked my colleagues who are med[ical] technologists and some of the pathology or molecular genetics staff to sit down and explain something to me, to help me understand the process or the method more deeply. (Betsy)

Betsy, like other interviewees, attempted to match her knowledge gap with others' expertise – framed as content knowledge – by querying professionals with relevant roles or titles. In this way, her choice of learning partner was dependent on the topic or question at hand. Caroline synthesized expertise and topic as conjoined criteria for identifying a learning partner, or as she said, "depending on the type of question I have, I'll seek out a colleague who has greater expertise or interest or background in that area" (Caroline). For Kitty, it was not the topical area but rather the extent to which the topic had been explored and resources were available which determined her choice of colleague:

> If it's a really well-defined thing that I can easily get all the information that I need on the internet, like FAP or something, then I don't really reach out. But anything like – I don't know – BAP1 or DICER1, I reached out about things like that because I think there's a higher chance that people know things from their center or their center has developed a way to screen people that I don't know or it's hard to synthesize quickly from the literature. (Kitty)

Interacting with others, particularly those with pertinent experiences – offered Kitty the promise of expedient answers on topics which, due to limited information available, are decidedly ambiguous and uncertain; she pursued colleagues for information not readily available through typical and formal means. The concept of access was corroborated by Betsy when describing the utility of colleagues as follows:

> I think I rely on that so much [because] it's available… it's immediately available. Going to conferences and taking courses and webinars are great and I do try to jump on them when they're available, but when you need an answer today in order to help a clinician and a patient, you go to your immediate resources. (Betsy)

Both Kitty and Betsy expressed a sense of urgency and need for expedient answers to questions regarding patient care. Timeliness of clarity on information pertaining to a patient's circumstance was necessary for professional learning to be effective in producing outcomes which could then be applied to the intended targets – active cases.

As an adjunct to expertise and availability, interviewees also evaluated colleagues as potential learning partners based on their capacity to provide alternative perspectives.

> I try to surround myself – and this is my work as well as my real life – with people that are not like me, because other people are going to have different experiences and different perspectives and surrounding myself with people like that will allow me to also have greater or more perspectives and just have [more] options of things to choose from. (Marianne)

Marianne sought colleagues who extended her thinking through comparison and contrast with their alternative views. Their perspectives animated her own critical analysis of the available alternatives.

Aside from more cognitive criteria, several interviewees owned that their decisions to go to one colleague versus another had more to do with existing personal relationships than expertise, experience, topic, or availability. Personal relationships were construed through different attributes: affinity or sensed connection - "You find people that you jibe with and people that you don't jibe with and you know who is best to go to with questions" (Louisa), and "I think sometimes it's how personalities mesh too" (Georgiana); trust - "You're going to the person you have the most trust in and relationship with" (Mary); and familiarity - "My relationship with the colleague, just as far as how often I interact with them, how close I am with them" (Darcy). Interviewees using personal relationship as rationale for choosing particular learning partners did so based on internal, emotive criteria of felt connection or affinity, trust, and familiarity in contrast to those using external, cognitive criteria of expertise, experience, or availability.

"Colleagues" defined. An essential competency of genetic counselors engaged in professional learning was the "ability to ask 'dumb questions in safe environment' such as with colleagues and others wrestling to understand the same information" (CIQ 22). Respondents frequently invoked the general term 'colleague' when naming others who participated in their learning. After consideration of expertise, topic at play, availability, and rapport, participants arrived at several categories of colleagues they deemed desirable learning partners – genetic counselors, lab personnel, and physicians.

Genetic counselors. Colleagues most often referred to genetic counselors generally, occasionally with the qualification of those working in a similar specialty or same workplace: "Discussions with other GCs who were in similar circumstances helped [me] to feel less overwhelmed and validated my feelings that it was difficult to absorb all of the new technology" (CIQ 102). Likewise, interacting with others of similar training and analogous work contexts was experienced as an emotional support. Colleagues could be depended upon to offer apt comparisons, generating comradery and diminishing a sense of isolation:

> All of the genetic counselors at my practice check in with each other to talk about which tests we are offering patients in different situations (i.e. when to offer a

> patient an expansive, pan-cancer panel vs. offering a more targeted panel) to make sure we are consistent in what we offer our patients. (Response 16)

The above quote demonstrated pooling of experience among a work group with the express intent of standardizing practice; yet similar to outcomes of collaborating described above, there was an element of social support – safety in numbers – regarding similar practices when there were multiple options. In addition to emotional and social support, colleagues were sources of feedback and insight: “I also relied on other genetic counselors I know professionally for feedback and information on their experience” (CIQ 345).

Laboratory personnel. A category of colleague related to those above yet distinct was genetic counselors working for genetic/genomic testing laboratories. Respondents often identified lab GCs as particularly helpful in providing resources and insight into new testing technologies: “GCs working in lab settings were helpful in accumulating and sharing data and literature on all genes included in panels” (CIQ 29); “I also spoke with lab GCs in certain situations to make sure we were in agreement about the best testing strategy in terms of samples to send and whether WES was most appropriate” (CIQ 220).

***Physicians**.* Many genetic counselors worked closely with physician colleagues to care for patients, dovetailing complementary skillsets. The synergy of practice extended to learning: “I think that ongoing conversations with other healthcare professionals, including the maternal-fetal-medicine physicians that I work with, have been and will be the most important step towards determining how I would like to begin to incorporate this testing option” (CIQ 24). This respondent looked to interactions with physician colleagues to facilitate practice adjustments in response to innovative testing. Other respondents appreciated more direct learning assistance: “One of the physicians I work with was far more informed in variant analysis, and so she volunteered to show me how to use some of the databases, etc." (CIQ 324).

Interdisciplinarity. An extension of interactivity overall, or perhaps a specification of it, in conjunction with the variety of professionals named as learning partners was further supported by a theme of interdisciplinarity throughout the datasets. Interacting with people in other professions or disciplines was experienced as an enhancement of professional learning. Interviewees endorsed the benefits of interacting with professionals from other disciplines: "It can't be just one kind of specialty – it has to be multidisciplinary" (Mary). Modern medicine was described as collaborative and the complexity of genetic conditions was seen as requiring a model of comprehensive care only achieved through interdisciplinarity:

> You have tunnel vision once you get into these specialties or rare disease specialties – the more specialized you get, the more tunnel vision you get… You forget the big picture. So when you get all of those people with tunnel vision in one room, suddenly you have a much bigger picture. (Charlotte)

Combining multiple perspectives fostered the needed holistic approach; each discipline had unique contributions to make:

> What I like about our group is that I do have all of these different types of people to work with. So we have a team of genetic counselors who are fabulous and can provide insight and perspective, but then we also have really experienced researchers, PhD candidates, post-docs, and people working in a number of different areas of expertise learning more about functional studies, like what would be done to further investigate this variant. Being exposed to and part of a team with so many different areas of expertise is really, really helpful and I think it allows me to kind of put genetic counseling in this broader context of the work that can be done, so it's not just kind of this silo of consenting patients and returning results, that I'm seeing all of the behind the scenes work and finding ways that we can participate in that as a genetic counseling team as well. (Lizzie)

Interdisciplinary interactions fostered comprehension of the big picture and broader context within which the work was being accomplished. Such insights were credited to the intermingling of differing approaches and angled perspectives, a circumstance which could not be generated from within a single profession.

Genetic counselors employed an assortment of learning strategies through interaction with others. Colleagues were situated at the center of these learning strategies, with participants cultivating networks of colleagues based on their expertise, availability, and personal connections. As learning partners, interviewees depended on colleagues to swap professional opinions, pool practical experiences, and provide feedback on one's professional judgment. Collaborating with colleagues in these ways leveraged interactivity as a potent facilitator and motivator of learning, at times further enhanced by degrees of interdisciplinarity among learning partners.

How Do Specialization and Years of Experience Influence Selection of Strategies?

Given the variety of learning strategies utilized by genetic counselors for professional learning, attention was paid to what might mediate preferences and choices of strategies. Questions surrounding specialization as a potential arbiter of learning strategies were founded in evidence that genetic counselors in different specialties identified distinct innovations and technologies – each with unique characteristics, benefits, and limitations – as influencing their practice, and therefore as potentially working to differentiate the applicability of some strategies from others. Additionally, specialization was admitted carrying indefinite assumptions of variation in the context, concerns, and challenges of practice, all of which could influence the efficacy of a particular learning strategy. Years of experience in genetic counseling was also assessed as a potential factor interceding the use of learning strategies; this analysis was grounded in curiosity as to whether preferences and practices of professional learning vary across cohorts which were expected to encounter different innovations, or perhaps a sequence of innovations, over time.

Influence of Specialty on Selection of Learning Strategies

Interviewees from all specialty groups utilized reading and researching and discussion with colleagues as foremost professional learning strategies. A greater proportion of those identifying with a clinical specialty (prenatal/reproductive genetics, cancer genetics, pediatric genetics, or multiple clinical specializations) described experiences of Constant learning related to their work compared to those in laboratory, research, or hybrid/expanded specialties. Those in clinical specialties also seemed more inclined to value Structure activities and advocate for Networking to facilitate professional learning. Alternatively, all participants working in the laboratory and research specialties spoke to the importance of Interdisciplinarity, both for their own professional learning and in the form of advice for other genetic counselors, whereas fewer than half of clinical participants mentioned this. Greater proportions of laboratory and research participants pointed to a Lack of resources specific to their learning needs as challenges to their professional learning.

Chi-square goodness-of-fit analysis of learning strategies across specialties as reported in 113 responses (one respondent did not identify a specialty) to the critical incident questionnaire found no significant differences among the following strategies: Pooling experiences, Swapping professional opinions, Attending national conference, Collaborating with GC colleagues, Discussion, Experimentation, Reading, and Lectures.

Influence of Years of Experience on Selection of Learning Strategies

The centrality of Discussion and dialogue and Reading and researching as integral learning strategies used by genetic counselors was reinforced as nearly all participants in all categories of years of experience mentioned using these strategies, and nearly all participants noted Practice as a primary source of initiation for the learning process. Inclination toward reflection appeared to increase over time as the proportion of participants advising others to engage in Reflective practice – and similarly the proportions of participants seeking Alternative perspectives through interactions with others – progressively increased across categories of increasing years of experience. An interesting contrast emerged between a greater proportion of those with fewer years of experience (0-4 years and 5-9 years) suggesting Cultivation of a formal network and a higher proportion of those with greater years of experience (10-14 years and 15 + years) suggesting Casting a wide net and Escaping the Bubble; this posed a potential variation between those at the start of their career seeking a strong foundational network while those more established sought to reach out and beyond perceived boundaries of the profession. Interestingly, a smaller proportion of those with 15 + years of experience described Pooling experiences as a learning strategy than the majority of those with fewer years of experience who did. Interviewees with 15 + years of experience also less frequently stated they sought Experience and Expertise in learning partners, whereas a strong majority of the other three categories of years of experience supported this idea.

Chi-square goodness-of-fit analysis of learning strategies across categories of years of experience as reported in 114 responses to the critical incident questionnaire found no significant differences among the learning strategies listed above.

Exploration of the influence of specialty and years of experience validated the universality of Reading and researching and Discussion and dialogue as strategies for professional learning of genetic counselors and suggested these strategies transcend contexts and time points of practice. There was some evidence of variations of learning strategies related to interdisciplinary, with participants in laboratory or research specialties and those with greater years of experiences embracing alternative perspectives and involvement of colleagues from other professions.

How Does Ambiguity Tolerance Influence Selection of Strategies?

Professional learning of genetic counselors, particularly enacted as a response to innovation, was pervaded by references to complexity, uncertainty, and ambiguity. Complexity was consistently painted as a feature of technological innovations and was believed to ratchet the baseline complexity of practice through their application. This complicating consequence was perceived to be augmented by a Lack of learning resources, namely pertinent information about, or colleagues with sufficient expertise or experience with, the innovation. These themes seemed to provide a premise for investigating the role of ambiguity tolerance in the selection of learning strategies.

Complexity

Innovations were noted to complicate and complexify genetic counselors' work and learning by increasing the number of and variation among available options in testing methodologies, introducing a higher degree of uncertainty and ambiguity in the results of testing, and – due to its novelty – being utilized without reference to established guidelines.

Genetic counselors were keenly cognizant of increases in number, type, and variety of available testing options. As “the number of laboratories, tests and technologies for molecular diagnostics… just skyrocketed,” (CIQ 102) respondents noted the challenge (and perhaps paradox) of choice: “Entire new options were now available for labs to offer and clinicians to assess and pts [patients] to repeat and insurance to deny” (CIQ 15). Number and variation were clear contributors to the experience of complexity:

> In some ways, it has complicated things. Before, there were 2 tests we offered: first and/or second trimester [maternal serum screening (MSS)] and [amniocentesis]. The explanations about what these tests were seemed relatively straightforward, for the most part. MSS seems to be quite similar lab to lab... A karyotype is a karyotype. But [non-invasive prenatal screening (NIPS)] has variations at each performing lab; they all offer something slightly different, or their technique is different (like massively parallel sequencing vs. [single nucleotide polymorphisms (SNPs)]). They may have different microdeletions that are available for testing. The accuracy may vary by a couple percentage points, in some cases. It is somewhat less universal. (CIQ 261)

Complexity was stated to occur at several points in the process of testing: when comparing tests (which test interrogates the differential diagnosis at play), assessing various methodologies as employed by different labs, contrasting limitations of tests based on methodological and interpretive protocols applied by each lab, and choosing which tests to then put into practice by offering them to patients.

The complexity of analyzing available tests was followed by additional complexity of analyzing results produced by the testing, a process first carried out independently by the genetic counselor as preparation for disclosure and again in dialogue with the patient during a results session. “Discussing the potential results and implications of testing has become more complex, primarily due to potential for uncertain or unexpected results” (CIQ 247). This respondent associated the uncertainty and ambiguity of the results of innovative testing with a perceived increase in the complexity of practice. Innovation in testing ushered in a phase of ambiguous results as technology supported the identification of novel findings for which interpretation lagged; results were being reported prior to the availability of the information necessary for full interpretation and were notated as a "variant of uncertain significance". Alternatively, testing would detect an important finding unrelated to the indications for testing – a result known as an "incidental finding" – giving rise to disclosure of information for which the patient is unprepared. As the quote above demonstrated, respondents' impressions of complexity were connected to variants of uncertain significance and incidental findings alike.

In other instances, complexity was felt when operating at the edges of standard practice, in absence of guidelines. One respondent phrased this scenario as follows:

> My current approach to genetic counseling is constantly challenged, re-evaluated, and refined due to the introduction of NGS/hereditary cancer panels and the lack of established guidelines for when to test, how to test, and how to manage both positive and negative individuals. (CIQ 321)

Without reference to objective, professional standards, the genetic counselor was tasked with personally negotiating decisions regarding innovative testing options: whether and how to utilize it and implement any subsequent results. The mental load of these decisions – with the added responsibility of making them autonomously – was perceived as a continuous challenge and revealed the ambiguity and uncertainty surrounding tests new to the clinic whilst little was still known about their utility.

Notions of increasing complexity were so strong as to make outliers of statements that situated this kind of change as status quo in genetic counseling: "We offer new testing and have a new way of counseling. This is not new, though, because this is what genetic counselors do - evolve" (CIQ 94). Evolution of this kind, whether a matter of adaptation or continuity of practice, was enacted as professional learning.

Lack of Learning Resources

Participants identified an important challenge to professional learning as a lack of resources to support learning. Working at the cutting edge of science and medicine highlighted the nascent state of knowledge in emerging areas of practice. Without reference to sufficient amount of data or people doing analogous work, typical approaches to learning such as researching pertinent information and seeking colleagues as learning partners were disrupted.

Concerns were raised regarding availability and access to informational resources when there was simply no precedent or established dataset. One interviewee found the biggest challenge to her professional learning to be "lack of information about a lot of the questions that I want answered… a lot of this stuff is so new that the information just doesn't exist" (Louisa). Another interviewee, Lizzie, concurred with the challenge of lack of information, expanding the conception to include lack of a canon of practice-based strategies to utilize or incorporate current information:

> One of the big challenges is that the level of learning that I'm doing now is beyond… there's no well-established genetic counselor practice for some of this like exome, genome… Even research – I think the research side of this is different than what research counseling has been in the past. This isn't a well-established prenatal category or cancer category. So I think that's the challenge. That there isn't this existing infrastructure to go to. It's almost like I feel like I have to be charting my own course a little bit, which can be a little nerve-racking… there's a lot of uncertainty I think with that too. (Lizzie)

The core learning strategies of reading and researching became moot when the objects of those actions – namely existing data – did not exist. The result was a clear sense of depending solely on one's judgment in ambiguous circumstances, an intellectually and emotionally challenging proposition, which likely compelled interviewees to turn to colleagues; yet even then, the novelty of the situation limited the availability of colleagues with useful input.

Both information and colleagues were integral to effective learning strategies, thus the absence of both significantly curtailed learning. Without colleagues as suitable learning partners, interviewees were denied alternative perspectives and interactivity. One interviewee explained that she could not find colleagues doing similar work:

> I also find that somewhat challenging for me as a genetic counselor in research, because there's not a ton of us out there, and so if I ever want to find a mentor or somebody to talk to that is doing something very similar to me, it's more of a challenge than finding somebody who's doing something wildly different than me that I could take small lessons from, but it would be beneficial to have somebody similar to me that I could big lessons from. (Marianne)

She here indicated a perceived, pervasive lack of important peers; they simply did not exit. While she leveraged the perspectives she gathered, she recognized an important limitation to how she could apply these perspectives and emphasized that key perspectives were missing. Another interviewee perceived that peers did exist, but access was limited, restricting the facilitating force of interactivity, due to the structure of the position:

> I'd say that a challenge I have now is because I work from home and work in the field, I'm not necessarily seeing my colleagues on a daily basis in the office. So whereas before, like when I worked clinically, I'd see the other genetic counselor every day and if I had a question, just in our day-to day interaction, I could easily run the question by someone. (Darcy)

Important motivations to interacting with colleagues were to seek alternative perspectives and pool experiences. When a colleague is in a dissimilar position or less accessible, the scope of application of the insights shared is limited, as is the subsequent potential to learn.

Ambiguity Tolerance Scores

Prior to assessing the role of ambiguity tolerance in selection of learning strategies, the ambiguity tolerance scores of 135 participants were analyzed. The average AT score of the sample of 135 completed assessments was 60.5 with a range of 35 to 85. Variation in AT scores by specialty, years of experience in genetic counseling, and age are included in Appendix F. Specialty – when assessed across all seven categories – was not a significant predictor of ambiguity tolerance (F=0.503, p=0.805); neither was dichotomized specialty in terms of primarily clinical ("prenatal", "cancer", "pediatric/general genetics", and "multiple clinical") versus non-clinical specialties ("laboratory", "research", and "other") approached significance (F=0.167, p=0.683). Years of experience as a continuous variable was also not a significant predictor (F=0.806, p=0.371).

Influence of Ambiguity Tolerance on Selection of Learning Strategies

Considering themes of complexity and lack of resources expressed by participants as challenges to professional learning, the potential influence of ambiguity tolerance on selection of learning strategies was examined by comparison across categories of ambiguity tolerance scores established to match quartiles in the spread of scores for all participants: less than 55, 55-61, 62-67, and greater than 67. Interviewees from all categories of ambiguity scores used Reading and researching and Discussion and dialogue as professional learning strategies; they all viewed practice as a source of learning and looked for expertise in learning partners. A greater proportion of interviewees with lower ambiguity tolerance turned to familiar resources when searching for information, whereas a greater proportion of interviewees with higher ambiguity tolerance preferred pooling experiences with colleagues. When giving advice, Take initiative and advantage was more commonly encouraged by individuals with lower ambiguity tolerance; this was juxtaposed by those with higher ambiguity tolerance endorsing a stance of Cast a wide net, seeing anything and everything as a learning opportunity. A greater proportion of those with higher ambiguity tolerance looked for a personal connection when choosing colleagues as learning partners, which aligned with their support of networking as a vital component of professional learning. A high proportion of those with lower ambiguity tolerance resisted speculation on alternative learning strategies were their preferred strategies unavailable, often responding with statements coded as Does not compute.

Chi-square goodness-of-fit analysis of learning strategies across categories of ambiguity tolerance as reported in 106 responses (eight respondents did not complete the ambiguity tolerance scale) to the critical incident questionnaire found no significant differences among the learning strategies identified in that dataset.

Summary of Key Findings

Comprehensive analysis of all datasets shed light on many elements of the professional learning of genetic counselors. Participants illustrated how innovations triggered learning processes and inspired personal reactions which then motivated them to seek opportunities to learn. They recognized evidence of learning when they found themselves able to adroitly answer questions – both their own and those of patients. Learning was also visible through outcomes represented by shifts in practice such as altered approaches to counseling or testing.

Though many learning strategies were described, none were more appreciated than the formal, structured, explicit strategy of reading and researching as well as the informal, intuitive, implicit strategy of discussion and dialogue with others. These strategies were so well-loved that participants were reluctant to consider alternatives and the strength of endorsement of these strategies transcended specialty, years of experience, and ambiguity tolerance. Furthermore, colleagues assumed a central position in professional learning. They engaged in collaboration via discussion to swap professional opinions and pool individual experiences into a collective repository. Many types of colleagues were invited to join in these exchanges, with reverence for those of other disciplines due to the fresh perspectives such interdisciplinarity afforded.

From initiation to adjustment of practice, genetic counselors noticed professional learning and its influence on their work, especially in response to innovation.

Chapter V

ANALYSIS AND INTERPRETATION

Professional learning of genetic counselors, particularly as a response to innovations arising in practice, while initially characterized by this study's findings, was further understood through interconnections with existing literature. Learning in connection with the practice context, learning strategies, the roles and influences of colleagues on learning, features potentially influencing learning preferences and practices, and prominent outcomes of learning are explored in conjunction with existing concepts and models from the genetic counseling and adult education literature bases.

How Do Genetic Counselors Leverage Learning to Incorporate Scientific Innovations into Practice?

Genetic counselors' professional learning was initiated by turns through technology, practice, and continuing education activities. All were subsumed in a context of complexity as numerous elements influenced learning and practice, which additionally manipulated each other. Within this context, participants explained the persistent use of reflection to apprehend concentrated elements of context, their reactions to these, potential learning which would follow logically from changes to context, insights emitted from learning strategies, and the results of learning for their practice. Reflection often revealed and reinforced motivation to engage in professional learning; self-direction was the propelling force driving learning forward. Professional learning in the context of practice and innovation was experienced not as episodic, but rather a constant state of reflective learning.

Learning in Context

Genetic counselors engaged in professional learning constantly – for a variety of reasons and to a spectrum of ends. Their learning was not neat, discrete, or easily categorized, yet it was timely, effective, and engaged. Unlike characterizations of professionals as separate and distinct from their environment and able to take objective perspectives (Boud et al., 1985; Fenwick, 2000; Schon, 1983), genetic counselors were intertwined with the context in which they simultaneously worked and learned, a circumstance akin to the enactivist perspective on reflection (Fenwick, 2000; Nicolaides & Yorks, 2008). Their embeddedness was constituted by a web of interconnections that attached each professional to their surroundings, including the social aspect – patients, colleagues, institutions, society – and objective aspect – technologies, systems, trends. Genetic counselors were immersed and inseparable from this context and its attendant features.

Participants highlighted several contextual features influencing learning, with various features differentially revealed through the three datasets of this study: the critical incident questionnaire, in keeping with the format of the instrument, depicted the influence of technologies as a primary contextual feature shaping professional learning; interviews centered on practice – the work itself - as the element of context most strongly initiating and shaping learning; and the database of continuing education units demonstrated learning within a well-defined regulatory system and structure.

Technology. In the critical incident questionnaires, genetic counselors described learning in response to many technologies. These technologies were discrete items, specific entities which were experienced as complex, unknown, or uncertain, extending and multiplying a range of considerations to assess and explore prior to incorporation in practice. Technologies compelled responses: “innovations force us to be in a constant state of evolution with our practices” (CIQ 57). Professional learning was considered a means of accomplishing an evolution of approach by curing the lack of immediate understanding which accompanied innovative technologies.

> Although I've always considered myself a self-motivated learner, this particular point in time and steps taken clearly showed me how critical it was to prioritize and actively seek such learning opportunities above and beyond what was available in a relatively informed/advanced setting, as the technology was changing faster than the knowledge was coming through into clinical practice. (CIQ 58)

The pressing need to respond quickly to innovation with learning harkened back to Miranda’s (2012) finding that technologies ignited the inspiration to learn among genetic counselors, or perhaps less positively, previous observations that genetic counselors desired learning to assuage discomfort with clinical application of new sequencing technology (Bernhardt et al., 2014; Machini et al., 2014). The strength of genetic counselors’ responses to technology – in this and previous studies – emphasized the potency of innovative technologies as contextual features driving their learning. What was not clear was the extent to which technology and learning enjoyed reciprocity; technologies influenced learning, but to what extent and in what ways might learning have influenced technologies, a bidirectional shaping similar to that described in the enactivist camp of learning from experience and the constructivist arm of literature on continuing professional development (Coady, 2015; Dirkx et al., 2004; Mott, 2000; Nicolaides & Yorks, 2008).

Practice. The workplace and work itself has been recognized as a source and setting for professional learning (Cervero, 1988; Knox, 2000; Schon, 1983); "the challenges and complexities of practice itself… are the richest source of learning for the professional" (Mott, 2000, p. 29). Indeed, genetic counselors – particularly interviewees – described their learning as interconnected with practice. In fact, patient care was keenly felt to initiate and motivate learning; it enhanced learning generally: "I learn better if I can relate it to a particular client or patient" (Mary). Clinical cases allowed learning to endure: "I feel like really the learning that sticks with you are going to be those cases that stick with you" (Lucy). Clinical work revealed how common professional learning was: "There's a lot of learning that happens just from day-to-day work… without having to attend a seminar or sign up for a webinar… I learn a lot just from the patients that I see" (Susan), and "on a case-by-case basis as new information comes to my attention, I would deem that learning" (Elinor). Encountering patients engendered motivation to improve through learning: "It's really that direct patient interaction… it's those pieces that are unclear that really make it clear that we are needing constant learning and kind of bettering ourselves" (Julia). Often, the need to learn was identified through realization that some component of practice was not understood: "We'll have a case that I don't understand very well, we'll have a patient coming with a medical condition that I don't understand very well – that's always a good opportunity for me to learn more" (Charlotte). In other instances, unfamiliar or novel genes, tests, results, conditions, or management prompted learning:

> One of the ways that I'm always reminded that I have to keep learning is when I see new gene names or testing panels that I'm not familiar with, or even conditions that I don't know much about and need to immediately figure out what that is and is it appropriate and how can we make sure that that's the right test for that patient. (Betsy)

> When I get a test result back and I have no idea what it means and, it's a gene I'm not familiar with and I don't know how to manage the patient, I don't know what referrals I need or anything. And then I'm really just starting from scratch, in knowledge of that. (Kitty)

Schon (1983) noted a persistent "gap between professional knowledge and the demands of real-world practice" (p. 45), a perspective endorsed by the comments of genetic counselors above. He and other authors in the adult education (Cervero, 1988; Daley & Mott, 2000; Schon, 1983) saw this situation as convincing evidence for the need for professional learning strongly aligned with and situated in practice to "promote the ability to work in the uncertain, confusing, and dynamic world of professional practice for the betterment of clients" (Daley & Mott, 2000, p. 81). Authors in the healthcare literature (Barwick et al., 2009; Pereles et al., 2002; Ranmuthugala et al., 2011) were found to concur. The participants in this study, as well as the aforementioned authors, were in agreement that practice – through its complexity, evolution, and uncertainty – inspired professional learning that was made more effective when situated in practice.

Continuing education. Participants described awareness of and responsiveness to a context of regulation of professional learning for the purposes of maintaining credentials such as certification or licensure. They spoke to both the "implicit responsibility" of lifelong learning as well as the "explicit requirements of professional standards and registration procedures" as characterized by Webster-Wright (2009). Whereas some participants experienced learning through requirement – "having to keep up with your certification… forces you [to learn] whether you want to or not" (Louisa) – others described learning and regulation as separate and serving different ends – "[webinars are] for CEUS, but they're not what I would rely on for my own learning, really" (Lizzie).

The database of continuing education units demonstrated how genetic counselors documented professional learning within a regulating system. Valuing of professional learning through different types of continuing education units was depicted by the range of entries which significantly diversified over the 14-year span of the database, yet showed a strong preference for formal activities offered by entities within the profession. Variation in types of activities and topical areas suggested co-evolution of learning along with technological innovations and the changing practice of genetic counselors. In contrast to objective data in favor of rather homogeneous functionality of the system through the dominance of category 1 CEUs, an interviewee demonstrated curiosity of implicit values revealed through different credit types:

> I think the idea, though, that all CEUs are equal, or that you get this amount of credit for this CEU and that amount of credit for that other CEU or that only these CEUs from these events counts is challenging. It's very hard obviously to say how CEUs should be apportioned and what does count. (Elinor)

Complexity

Genetic counselors enacted learning strategies within a professional landscape fraught with complexity. Societal, professional, institutional, and technological components of the environment shaped genetic counselors' practice, especially by requiring professionals to grapple with a rapid rate of change and increasing number of constituent parts in the system to which learning was aimed at helping them adapt.

> Previously, we may have had a handful of tests to offer families in the evaluation for a rare genetic condition, and if an answer was not gleaned from that testing, we would often discuss the limits in current knowledge and the possibility of better testing in the future. Often families were okay with the unknown, as hard as it may be. However, with the availability of [whole exome sequencing], often we could not directly state what we would expect to find in the initial counseling session, the counseling time increased to discuss details regarding potential results, and often families came into the session possibly expecting more than a potential for

> "unknown"... I often felt that in the current clinic setting – crunched for time as the complexity of genetic tests increased – that there was not nearly enough time for a patient to gain a true understanding of what all could come from this type of exome testing. I remember feeling that I could not possible keep up (or my patients up) with all that could arise. (CIQ 256)

Genetic counselors were keenly aware of the shifting landscape and evolving components of practice. They felt complexity directly: “I also had to find ways to modify my counseling to be able to address all the possible topics that can come up regarding screening, and to do it in 40 mins without compromising psychosocial counseling and focus on my patients needs and desires” (CIQ 85). They attributed the bulk of complexity to the science and technology underlying diagnosis of and testing for conditions with genetic or genomic contributions. The enactivist perspective on experiential learning shed light on parallels between the complexity of context (technologies) and the felt complexity of practice by describing frenetic exchanges rather than transactions between variables within a system: “interpenetration of boundaries is part of the messiness of complexity and is indispensable” (Nicolaides & Yorks, 2008, p. 55). This messiness was considered to normalize complexity perceived by genetic counselors when incorporating innovations into practice, and the complexity, ambiguity, and uncertainty that companioned the process, as described by participants and in the genetic counseling literature (Bernhardt et al., 2014; Bower et al., 2002; Furnham & Marks, 2013).

Reflection

Nearly all genetic counselors’ professional learning was infused with some type of reflective thinking; participants described extended, careful rumination on many topics. Reflection was used to ascertain, interpret, and apply innovations, personal thoughts and reactions, self-assessments of knowledge or skill levels, inclinations toward learning, and was employed as a conscious learning strategy. While traces of reflection's utility were streaked throughout this study's data, participants often did not name reflection directly or in any detailed way, in keeping with observations that "reflection, and its role in learning, may not be obvious to learners; it may also be a tacit process in experienced practitioners" (Mann et al., 2009, p. 614). Despite – or because of – reflection's intuitive, subtle, nuanced presence, it enjoyed a singularly unique prevalence and pervasiveness as an approach to professional learning. Reflection was applied in numerous ways and to an array of ends. The lack of coherent, conscious understanding or application – as shown through muddled uses of the terms "reflection" and "reflective" – corroborated research on reflective practice in healthcare professions that found significant diversity in definitions (Mann et al., 2009). While it was clear that participants and healthcare professionals overall incorporate reflection into their work and learning, the process or phenomenon of reflection remained significantly complex as to escape operationalization. Participants in this study revealed insights on aspects of the ubiquitous influence of reflection by relating indications of it being activated, recognizing when it occurred subsequent to or simultaneously with experiences in practice, appreciating how it involved others, detecting when it informed new actions, and exploring its depth and intentionality.

Indications of. Genetic counselors noted the presence of reflection and its connection to their learning through moments of surprise or realization: "When you're teaching, questions arise that you don't have the answer to, which then drives you to learn the answer, and it maybe something that you never knew that you didn't know" (Darcy). Reflection produced the realization and was viewed as the means carrying forth: "where you think you're going to talk about one little thing then you realize, 'Wow, there's actually more to it than I thought!' And to do it any justice, I better learn a little bit" (Charlotte). Reflection generated self-identified discrepancies, gaps, questions in need of redress for some; for others, reflection clarified impulses or inclinations to perform specific roles or tasks in the scope of their usual work:

> I have these epiphanies that I want to either participate in somebody's medical care, especially if it's a multidisciplinary care, or I want to explain something that's a little bit out of my comfort realm to people – what I end up realizing is that I don't really know as much as I think I do, and so I end up having to learn. (Charlotte)

> Whenever we have a new batch of results that I have to assist in interpreting, or when we have our group meetings when we're all discussing those results… I've always known that that's where my weakness was and that's what I needed to learn, and I've forced myself to ask basically every question that I have. And so that makes it apparent to me and to everybody around me that this is what I am learning. (Lizzie)

For still others, reflection was described as a kind of idea-generating reverie without pre-determined purpose:

> It was one of these things where somebody's giving a talk and ideas are kind of spiraling in my head, and I'm going, "Oh, I wonder if we've looked at this or if anybody else has looked at this?" It was kind of spun off of a presentation that somebody was giving. (Margarette)

> For you to do learning, it's any moment of any day. And a lot of times, what we do is muscle memory, when we see a patient and we go on to that spiel that we always do, or when we're going through our email chain and there's just certain tasks that are very repetitive. When I realize that I need to slow down and think and take a breather, that's the first start that I have opportunity to learn ahead of me. And then I also take that step back again and say, "Is there some opportunity here that I can dive deeper in an area where I know I need to learn more?" (Henrietta)

Regardless of the timbre of reflection – pointed surprise, purposeful consideration, wandering speculation – it was evident that genetic counselors conceived of reflection as an attentiveness, focus, and awareness of themselves and their work that was part of their learning.

Separate from. The most detailed accounts of genetic counselors' use of reflection for professional learning were analogous to the framework of reflection constructed by Boud et al. (1985), as processing, analysis, interpretation during which experience was placed in full view and sharp relief so as to manipulate it in search of better understanding. Experiences served as the matter or material of analysis – as object separate from subject perceiving it – and held up for examination, considered for emotive impact, and re-interpreted after the experience had concluded (Boud et al., 1985). Experience took on an information or data-like quality during this version of reflection, "reflection-on-action" in Schon's (1983) formulation, a summarization or report of what was. Participants in this study offered suggestions of approaching experience in this way – "the most important information was ultimately our experiences" (CIQ 77) – as Miranda previously described genetic counselors to do ("professional development of expertise occurs through critical reflection upon the experiences one accrues" [Miranda et al., 2016, p. 767]).

Genetic counselors used debriefing practices during which they reviewed prominent or unique aspects of their work or learning, considered their thinking and actions at the time, and re-evaluated it by exposing the recollection to a barrage of questions:

> Going back and dissecting, could we have changed how this patient perceived things? Could we have made things any better?… Introspectively thinking of what did we do the first time that caused this kind of reaction versus now we're getting such positive feedback. (Mariah)

This series of questions illustrated a thought process enacted after an experience was completed to aid in its interpretation and prepare alternate approaches. Reflection served as a waypoint between the immediate past and analogous future scenarios, offering new ideas or alternatives for thinking and acting during subsequent iterations of the circumstance.

When describing reflective processes, genetic counselors described returning to their memories of experiences and re-evaluating their impressions and understanding of the experiences, yet they did not often speak to assessing their emotional responses. One notable exception to the absence of an emotional component of reflection in this study's data sets was found in genetic counselors' descriptions of the impact of genetic technologies on their practice in the critical incident questionnaire. A striking range of emotions was noted as genetic counselors revisited those experiences and retrospectively evaluated their impact. Though highlighting emotions, the critical incident questionnaires offered little in the way of detailed descriptions of the rest of the reflective process. However, taken together, the critical incident questionnaire and interviews provided evidence of all three components of Boud et al.'s (1985) framing of reflection.

Concurrent with. Abiding concerns about partial perspectives and incomplete view of genetic counselors' use of reflection, in conjunction with limitations to Boud et al. (1985) and Schon's (1983) framing of reflection as individualistic and based on false distinctions between the thinker, experience, and context prompted analysis of the extent to which participants' descriptions aligned with theories of reflection from the enactivist perspective which acknowledged complex and contextualized components: "learning is thus cast as continuous invention and exploration produced through the relations among consciousness, identity, action and interaction, and objects and structural dynamics of complex systems" (Fenwick, 2000, p. 262). Timing of reflection – whether it followed or occurred in tandem with the experience it examined - was taken as an important criterion on which accounts of reflection would be assessed.

Rather than subsequent to and separate from experience, reflection was recast as a continuous awareness, a perpetuality reinforced in this study: “I think the most important action is longitudinal learning… have to stay on-top of changing technology and keep assessing and improving” (CIQ 87). As a constant process, reflection maintained concurrent properties of being fixed (ever-present) yet dynamic (fluctuating focus). By reflecting in real time, genetic counselors facilely analyzed the experience in relation to its context:

> I have not yet come to a conclusion on this particular offering, but have been deeply considering the potential impact of the availability of this additional information as a screening test in the context of clinical validity/sensitivity/ specificity of the test and when to offer it (especially thinking about insurance coverage if 'typical' NIPT has already been completed). I will have to change my practice in terms of figuring out how and when to discuss this new version of NIPT to allow patients to have the greatest autonomy while selecting options that make sense in the context of their values and clinical history. (CIQ 24)

This participant detailed an ongoing, in-depth analysis which connected features of the innovation (technological specifications, clinical availability and utility) and contextual implications of the innovation for multiple areas of practice (insurance, existing technologies, decision-making strategies, patient values and experiences). Both the timing and interconnectedness of this reflection exhibited negotiation of multiple features within context concurrently.

Analysis of genetic counselors’ take on reflection was therefore found to demonstrate persistent, merging, synthesizing attention that mingled personal, contextual, and synergistic ideas. Perhaps the most illustrative of examples of complex reflection was the one below provided by an interviewee:

> I want to learn where my weaknesses are, “what I’m doing wrong?” I’ll always ask that question or “What could I have done better?” Because that’s something where I find most people you interact with won’t give you that kind of feedback… But it’s really what makes you successful. You have to know those things and it’s not always easy to see in yourself. So I think one of the things that I’m hoping to get – I guess

> I've never thought about this or verbalized it, but now in thinking about it and talking to you – is that having their critical feedback of me and the way I approach things, whether it's my writing or my speaking or negotiating or whatever it is, I want them to push me to be better as I'm trying to learn more. I know that I'm naturally curious, so I'm going keep asking them questions, but I want to make sure I'm on the right track and I want to do a good job… They're investing a lot of time in me when they're mentoring, so I just want to keep pushing and improving. (Fanny)

This interviewee's description of learning – include the component of meta-awareness of reflection on reflection during the interview – was taken as evidence of reflection-in-action as she merged attention to herself as learner, the learning process, contextual contributions to learning, and the experience of describing her learning.

Intentionally. The complex, contextualized construction of reflection was believed to be in keeping with definitions found in the genetic counseling literature (Miranda et al., 2016; Zahm et al., 2016) that used "self-reflection" to describe "a willingness and openness to continuously engage in a process of critical analysis of one's thoughts and/or behaviors in order to understand motives and continually 'self-evaluate'" (Miranda et al., 2016, p. 772). Again, persistent, timely evaluation of multiple attributes was emphasized, though with less direction to incorporate contextual elements. What was perhaps missing from these calls to self-reflect was an incitement to intentionally extend beyond natural thinking procedures – purposefully develop reflective abilities – to realize reflection's full potential for learning. Several authors in the adult education literature asserted the need to grow reflective capacity (Murdoch-Eaton & Sandars, 2014), with Eraut specifically contending that seeking out and testing assumptions was an integral function of reflection (Eraut, 1994). Participants in this study spoke to sharing this value of questioning assumptions:

> I think the key thing is to, well to kind of push yourself out of your comfort zone a little bit and ask the questions that maybe you kind of wish you already knew… To not rely on any assumptions that you already have, to be sure to kind of examine your own thought process really carefully. (Lizzie)

Careful, probing reflection of this kind was believed to be a type of constructivist, meaning-making activity: "learners engaged in meaningful learning craft their own idiosyncratic significance for new information, making the learning both new and more relevant through its application to a specific context" (Mott, 2000, p. 27). Rather than reflecting on the same plane of understanding to reinterpret or rework strategies, questioning assumptions was perceived to move the reflective process to more complex, more insightful, and more meaningful learning territory. Genetic counselors demonstrated reflection of the latter sort:

> The experience helped me to always look for underlying issues that are impacting multiple outcomes. It can be so tempting to jump right to solutions, but by taking time to understand the true underlying issues and learning from others helps to envelop a more elegant solution. (CIQ 258)

Participants relayed their appreciation for reflection yielding refined understanding, yet understanding was often not sufficient, as several genetic counselors pointed out the need for reflection to be affirmed through action.

Affirmed by. Theories of meaning-making in the adult education literature stated that meaning was made when learnings were applied to the context of practice (Coady, 2015; Dirkx et al., 2004). Participants directly corroborated such views:

> From my perspective, reflective doesn't just mean thinking about what you've done and what you have learned from this experience, although it does… Part of that is, are you going to take that a step further? I learned that I need to know a little more about X, Y, or Z, and then how are you going to go figure out how to learn more about X, Y, or Z. Or I took away from this that I need to change how I do things in these settings... How are you going to go about making that change? From my perspective, it's take a very broad approach to what you mean by learning, reflective about all of your experiences, it doesn't mean just about what you're doing in clinic, but it's, "what have I learned from this internal review board meeting?" and making a plan for how are you going to use that, what I've learned. So, that would broaden your view of what learning is and incorporate that into having a reflective practice

> and then make sure you think about follow-up with what you've learned, either how are you going to do more or how are you going to incorporate it. (Anne)

This interviewee expansively describes reflection's internal aspects of careful analysis as well as external applications to contexts through direct and indirect connections, one situation to another, thought to action. Similarly,

> Every talk that I might go to or every kind of set of information that I might learn, I try to like pull out the key points of how does it personally affect me and my work flow or my daily work, is there something that I could do differently or alter or change… if nothing else, I'll mark down what resources were mentioned in the talk or at least who gave the talk so when I know that something came up, and I'm like, "Huh, I think I remember learning about that at some point," I have a reference to go back to when it actually does apply to what I'm doing in that moment… (Susan)

Here, consideration was given to the importance of contextualization. Adult education stipulated a social component to context, which was validated by participant accounts of including others in their reflective processes. One interviewee suggested reflection was bipartite: "it's a two-pronged approach: do some introspection and recognize your limits, but then also be so comfortable that you show them to others" (Mariah). That genetic counselors work in social environments and can then connect their reflection with that of others was duly noted:

> I've just been trying to absorb and pick apart every conference call we have, go through, "OK, what was good, what was not good?"… Afterwards, we again did the debrief thing where we went through, "OK, how do you think it went?" And I just really picked their brains about it so that I can learn how to better navigate this new kind of world that I'm entering into. (Fanny)

Genetic counselors used reflection as the foundation of their professional learning. Their reflections began with realization of unknowns or limitations, recognition of aspirations, or mere reveries as they played with new ideas, novel amalgamations of existing concepts. Reflection, in aiding the identification of these initiators, facilitated itself. The reflective process proceeded at variable rates and relations to the experiences at issue:

by following an experience which was then objectified, reified, cordoned off from the individual for examination; or by occurring in tandem with experience, concurrently, with presentness enabling ties to context, complicating and complexifying the analysis, and yet, thereby magnifying authenticity and yield of reflective efforts. Reflection was still further enhanced by intentionality, awareness that reflection itself benefitted from reflection – an airing out, shining light on assumptions. Finally and fully, reflection was actualized when internal thought converted to external actions realigned and fastened back to the world of practice.

Motivation

Reflection of the type described above required significant effort and investment, as did all professional learning. To muster the necessary activation energy, participants noted motivations of patient care, personal interest, and validation as powering their learning processes.

Patient care. Genetic counselors were motivated to learn to better serve their patients: “so I could counsel my patients” (CIQ 100), “to educate myself so I can then educate my patients” (Lucy). Counseling and educating were goals in keeping with the definition of genetic counseling (NSGC Definition Task Force, 2006), and participants often cited patients as the ultimate justification for learning quickly and well: “as things present themselves, I want to make sure I’m covering the basis for the patient and not missing anything that’s avoidable” (Caroline). Both the critical incident questionnaires and interviews garnered verification of genetic counselors’ commitment to doing good work for those who depend on them:

> When I get the result back, I want to call the patient soon, so I'm trying to learn… it's often like I'd drop anything else I'm doing that's not urgent, I learn as much as I can so I can call the patient within 24 hours and actually know what I'm talking about. (Kitty)

Previous research on continuing professional education cohered with the importance of clinical care expressed by participants in this study through analysis for potential correlation between learning and change in patient outcomes, though with little success (Bluestone et al., 2013; Cervero & Gaines, 2014; Cervero & Umble, 1996; Robertson et al., 2003). The current study similarly found participants speaking to changes in professional performance (or knowledge, skills, and attitudes underlying performance) following learning – notably adjustments in counseling approaches or testing strategies – yet there was little to no connection made between professional learning and specific patient outcomes.

Personal interest. Several participants noted they were motivated to learn based on personal interest in topics arising in the context of patient care; these topics were perceived as falling outside the purview of their expertise, hence they were not required subjects for professional learning. In these instances, learning was motivated by curiosity or for personal edification.

> I think there's certainly some self-driven learning… if you have an unanswered question, then talking to more knowledgeable colleagues or looking things up in general. So, looking up a cardiac MRI in general, find out what the test is, what is it generally used for, and how could that then be associated with the disease process that the patient. (Darcy)

Though the learning resulted in knowledge peripherally connected to practice, it was primarily a desire to better understand a greater extent of the context of patient care that motivated this interviewee. Similarly, another interviewee argued learning

> Just my own personal interest… I'll see patients who have very complex medical needs that might not have anything to do with genetics, but I'll have to understand…

> "I don't understand what pulmonary hypertension is, or why that's such a big deal. I guess I better look it up." (Charlotte)

Learning of this kind was motivated by a desire to extend one's understanding of the circumstances of practice beyond those aspects for which the genetic counselor was directly responsible, in direct agreement with Miranda's (2012) finding of motivation to continue learning as a characteristic of expertise in genetic counseling.

Validation. Genetic counselors were often compelled to engage in professional learning to gather alternate perspectives on their own judgments and approaches: "sometimes you do your drive-by conversations just see if that's what somebody else would do" (Mary). Through comparison with additional information or the views of others, participants sought and gained validation of experiences of struggle or challenge, knowledge and judgment of best practices, and verification of the inherent fascination of the work.

Validation was deemed important when adapting to innovations as it provided comfort when enduring challenge: "discussions with other GCs who were in similar circumstances helped [me] to feel less overwhelmed and validated my feelings that it was difficult to absorb all of the new technology" (CIQ 102). Exchanges of opinion occurred locally among colleagues and at national conferences:

> Attending the NSGC [Annual Education Conference] was helpful in that it addressed many of the questions being asked at my institution. The success stories presented in overcoming some of these practice challenges provided insight into bringing these solutions to my practice while discussion of lingering challenges at least validated my feelings of insecurity/doubt due to lack of established guidelines. (CIQ 321)

A sense of consolation was derived by recognizing a collective struggle to achieve and maintain competence, in a manner quite similar to that described by Wenger (2000) when he suggested that professionals learning in communities of practice engage in a process of apprehending how competence was characterized by a group of people, then reconciling the social standard with one's personal experience. Interestingly, Pirzadeh et al. (2007), in their study of genetic counselors' values, identified achievement as a highly ranked value, which they defined as displaying competence in accordance with social standards. Validation as a motivation might then be considered to foster feelings of achieve in genetic counselors, further supporting through positive reinforcement an individual's motivation to continue learning.

Hints of comfort from recognition of shared experience were further confirmed by participants' statements of engaging with others to achieve consistency of practice:

> All of the genetic counselors at my practice check in with each other to talk about which tests we are offering patients in different situations (i.e. when to offer a patient an expansive, pan-cancer panel vs offering a more targeted panel) to make sure we are consistent in what we offer our patients. (CIQ 16)

Consistency, in this instance, was interpreted as a proxy for validation that one shared standards of competent practice with the group as it operated as a community of practice to adapt to a recent technology. Consistency with normative expectations and past experiences was assessed, as one interviewee noted,

> [I] made sure that I was in alignment with what they were doing and we weren't going to be completely out in left field with how we were approaching it. So I wanted to make sure we were kind of going along, you know, with the standards… I was [also] learning, not necessarily how our specialty should be, but how has it been done at our specific facility in the past. (Julia)

This was a process of seeking knowledge from others in similar circumstances, like previous reports of communities of practice in healthcare "learning together through peer support, knowledge sharing… and knowledge creation, through development of new resources" (McCreesh et al., 2016, p. 6). Validation through consistency was thought to be similar to efforts made to confirm appropriateness of an individual's thinking: "reaching out to others doing similar things was most important in making sure my counseling and actions were appropriate" (CIQ 46). Appropriateness was constituted by consistency with the opinions and behaviors of others:

> There will be a lot of times where I feel like I have a thought about what I think needs to be done, but I'm not entirely sure if I'm missing something from a different perspective, so I will often go to the other physicians, whoever I'm working with that day to make sure that I'm thinking about it appropriately. (Georgiana)

That participants were not alone in their thinking, struggling, and strategies demonstrated the effects of validation as motivation for ongoing professional learning.

For some genetic counselors, rather than motivation arising from need for support during challenging circumstance, validation was received as encouragement and a sharing in the enjoyment of the work:

> I like working with other GCs for a lot of reasons, but also because if something new comes up and I talk to them about it, I'll usually say, "Wow, I got this really unusual result. I've never seen something like this" and they will get really excited about it, and then it's a more motivating personal environment, when your coworkers are like, "Oh, did you call out that result? How did it go?" or "What are you going to do for you?" or honestly just the informal excitement about learning makes you more validated in it. (Kitty)

This interviewee aptly shared the motivating energy for learning she derived by interacting with her colleagues.

Self-direction

Several theories of continuing education named self-direction as a key component or quality of the learning of professionals (Bluestone et al., 2013; Cervero & Daley, 2016; Eraut, 2012; Mott, 2000). Cervero and Daley intriguingly queried "whether individual professionals will engage actively and assume responsibility for this level of independence in managing their own learning" (Cervero & Daley, 2016, p. 16). In part, Pirzadeh et al. (2007) answered for genetic counselors when they identified self-direction as one of their core values. Participants rejoined in chorus to affirm the centrality of self-direction through statements regarding accepting ownership over their professional learning.

It was framed as an evident truth that "self-directed learning is a requirement in such a rapidly changing field and the need to be open to change" (CIQ 236). Participants referred to taking control: "I realize that I'm self-controlling my learning… then I make the active choice of what do I need to do to learn more" (Henrietta), assuming an active stance toward their learning so as to "realize something I don't know… take that initiative to then go figure it out myself" (Caroline). Self-direction was then linked with reflection as "experience has both an active and a passive component, and is comprised of not just what has happened to a person, but also what a person does in interaction with the environment" (Nicolaides & Yorks, 2008, p. 52). An active stance and initiative lent themselves to an impression of ownership as genetic counselors embraced a sense of professional responsibility which they enacted through professional learning activities, individually or with a group:

> When I'm doing something active where I'm seeking out to learn… I'm 100% research, and so most of my learning that I'm doing is very active in that I'm reading journal articles to inform myself about a grant that we're writing, or to inform another paper that we're writing, or it's attending meetings and presentations where new knowledge is being shared with me... it's intentional learning, not so many "A-ha" moments for me. (Marianne)

> We consulted professional opinions on how to proceed with panels and had a number of internal meetings to discuss adding panels, adjusting our process, and ongoing case discussion. We were a small department, so all change was initiated and carried out by us. We developed new processes and counseling aids, consulted the literature whenever possible. (CIQ 48)

Not only did genetic counselors relate instances of self-directing their learning, but they did so with gusto and multiplicity, clearly demonstrating a willingness to accept the responsibility of oversight as questioned by Cervero and Daley (2016). Intriguingly, though, was Pirzadeh et al.'s (2007) speculation that professionals' values – such as self-direction – could in fact be subject to change in concert with changes in contextual features.

Constancy

In much that same way that Schon's conceptualized expertise as "something which was once constructed and may be reconstructed" (Schon, 1983, p. 296), genetic counselors pursued professional learning as an iterative process given that "things are coming up that are new… new testing strategies, so there's always the learning that's continuous" (Julia). The theme of constant learning confirmed previous findings of persistent pursuit of learning as a mark of genetic counselor's expertise (Miranda, 2012) and as a solution to discomfort arising from modern technologies (Machini, 2014). Genetic counselors seemed invigorated by constant change – "everything we do is a constant learning process, it's probably the best part of my job, though, because it's not very interesting to never be challenged intellectually or never learn anything new" (Charlotte) – consistent with Miranda's (2012) finding that "learning is an inspiration and motivation, and it is fueled by an innate curiosity" (Miranda, 2012, p. 108).

The speed of change in the context of practice was also frequently cited as shaping professional learning. Genetic counselors explained matching the pace of their professional learning with the rate of innovations:

> It's changing so fast, everything… I feel like very little that I need to know now I learned about in school. I think that coming away from my formal training, the best skill that I gained was to learn how to learn, to find my resources and to know how

> to figure things out. Probably everybody has that experience when we graduate from school, go in your first job, and then "Oh my gosh, nobody taught me this!" But, you feel like you have the resources to find that information. So I think the biggest challenge is really, within the last five years, to completely understand next generation sequencing technologies and the limitations and the different kinds of platforms. I think just the rate at which we have needed to learn things has probably been the biggest challenge. (Betsy)

Though participants described vigorous pursuit of professional learning, they seemed to question the meaning or feasibility of expertise in the complex, fluctuating context of their practice: "it's never possible to fully master anything because this field and its practices/information changes constantly" (CIQ 13). The constancy of demands which the context placed upon the professional removed focus from some idealized endpoint of expertise: "my practice is constantly changing. There is no right answer anymore. I learned that as technology advances, clinical genetic becomes more complex, not simpler" (CIQ 27). In absence of an achievable goal, attention came to rest on the process of learning, on embracing

> A culture or a mindset that's ingrained since training, that you're never going to know it all, you're always going to be continually learning, these are the foundational skills that you need to be a lifelong learner... And continue to have the curiosity… (Susan)

From this position, genetic counselors accepted the need for constant learning. Constancy was noted in all three data sets: proportionately prominent in the critical incident questionnaires and interviews, frequently co-occurring with comments regarding the rapid rate of change in the field, and quantitatively by the strengthening stream of entries submitted to the database of continuing education unit credits. The immediate notion that professional learning would resolve the contextual complexities of practice raised questions as to the validity of such an association.

What Strategies Do Genetic Counselors Utilize for Continued Professional Learning?

Genetic counselors utilized multiple strategies for continued professional learning, all enacted within the framework of a reflective process, often conducted in the context of practice. Nearly all participants relied on reading and researching to maintain a scientific knowledge base consistent with changes in the current context of practice. They also depended on discussion with colleagues to facilitate resource identification and sharing, assist with interpretation of that information, analyze practice-based challenges, offer alternative perspectives, and pool similar experiences: "discussing approaches to cases with my colleagues was most helpful, and working on counseling strategies with each other. I was able to learn from their experiences and gain information that I had not considered/come across while doing my own searching" (CIQ 256). Reading and discussion with colleagues were often employed in tandem and displayed a permeability such that information and insight gained through one strategy was often consolidated by incorporating the other strategy. These were such predominant professional learning strategies that they were endorsed by participants of all years of experience and specialty. As one participant succinctly stated, "it's usually just people or papers" (Margarette).

Reading and researching's emphasis on information-gathering was compared with Schon's (1983) concept of technical rationality; both shared the goal of maintaining a constant level of expertise through consistent, unvarying strategies. Technical rationality was understood as follows: this "professional activity consists in instrumental problem solving made rigorous by the application of scientific theory and technique" (Schon, 1983, p. 21). Indeed, genetic counselors noted gaps in their knowledge and applied the techniques of reading and researching to address perceived gaps, recapitulating the ingrained strategy of using static information to answer each question. The independent nature of this learning strategy correlated with Argyris and Schon's (1974) model I theory-in-use in which learning was depicted as a private, "self-sealing" process, and subsequently resulted in changes to knowledge, but not attitudes, related to practice.

Though reading and researching may have limitations as learning strategies, they were quite commonly cited throughout this study's dataset, appearing in critical incident questionnaires, interviews, and the database of continuing education unit credits through participant in the Journal of Genetic Counseling's CEU program. The prevalence of this strategy was explained by its efficacy in resolving fundamental learning needs – such as for additional information to support reflection and guide future action, or to calibrate action in shifting context. Eraut succinctly defined continuing professional education as when "people recognized a need for some additional knowledge… to improve the quality of their work, and pursued their goal by a combination of self-directed learning and taking advantage of relevant learning opportunities" (Eraut, 2012, p. 22); so too were genetic counselors viewed as enacting reading or researching in response to a perceived need – recognized via reflection – for additional information to support their practice and henceforth gathered that information from readily available sources of literature, online resources, and colleagues. Thus, reading or researching was identified as an instrumental learning strategy in that it was essential to genetic counselors' professional learning.

Though genetic counselors adroitly engaged in learning on their own through reading or researching, they readily complemented this with social strategies, primarily through discussion with colleagues. Cervero noted that, "[t]o the extent that professionals can more consciously describe how they reflect and what that teaches them, they can more readily employ that form of knowing in new situations" (Cervero, 1988, p. 45). The involvement of others in discussion on learning assisted with application of the learning to practice, constituted by a series of new situations. The social learning strategies of genetic counselors were also better understood by reference to Argyris and Schon's (1974) model II theory-in-use, in which learning was conducted through interactive processes, with one's perspective tested publicly through exchange with others. Comparison and contrast of differing perspectives allowed participants to test their understandings and approaches to practice. As Argyris and Schon commented that model II theory-in-use was especially effective for challenging problems (Argyris & Schon, 1974), it was unsurprising that genetic counselors turned to discussion with colleagues to sift through complexities of innovations, of which genomic technologies appeared to qualify by virtue of genetic counselors' reactions to them in this study.

Permeability

Genetic counselors seamlessly engrossed themselves in learning by any means available and appropriate. Their pragmatism produced experiences of learning that – rather than being clearly defined, linear, and sequential – displayed a kind of permeability as they moved fluidly through multiple methods.

> I spent a lot of time prepping for the case as well as researching mid-case as new information was shared with me by the patient. Spoke to about three genetic counselors on the phone, it was a lot of learning from different sources – patient learning, coworker learning, online research, databases, things like that. (Caroline)

Similar to Caroline, many genetic counselors put both reading and discussing to work in various combinations. Some pursued both concurrently by collaboratively exploring the literature: "we really have a great deal of group discussions and try to get into the literature together" (CIQ 50). Some gathered information on their own first, then reached out to clarify interpretation of that information through discussion: "my preferred way of learning is to get some information to start, process it as much as I can, and then talk to someone about it" (Henrietta). Others extended the radius of colleagues they turned to, from local to national through online discussion forums: "I would say my first stop is typically either PubMed or UptoDate, or Reprotox, and then will often go to my colleagues, and then if they don't know, [I] will usually go to the listserv" (Georgiana). Online resources proved important media for facilitating both reading and discussing.

> I obviously make a lot of use of online resources, all of the different variant databases and publications and articles – those are all great resources, but I still find myself actually kind of doing that little bit higher level critique of reading an article and saying, "Well this, I'm wondering is this like a legitimate conclusion that they made… It seems like they're missing this… Is that" and then checking with someone, like "What was your impression of this?" (Lizzie)

The genetic counseling literature included an account of a continuing education opportunity which, through its various components, demonstrated the power of permeability of learning strategies; the course combined distance learning, in-person training, and continued online support to achieve increased knowledge and enhance knowledge translation to practice (Blazer et al., 2011). This was viewed as a formalization of the informally constructed system of strategies described by participants above.

Complementarity

Permeability of learning strategies was coupled with awareness that multiple strategies –those structured, explicit as well as the intuitive, implicit – complemented each other: "there's no one thing you can do to learn all you need to know" (CIQ 87). The genetic counseling professional development literature declared this by offering two dichotomies of types of professional learning: formal or informal (Miranda et al., 2016) and deliberate or unexpected (Zahm et al, 2016). Participants were found to share the language of "formal" versus "informal" learning strategies, most often when asked to describe the frequency of their learning. Interestingly, formal learning strategies were easily recognized and named; it was often when considering frequency of learning that informal learning strategies were identified.

> At least once a week, we'll do some kind of learning opportunity, whether it's an online webinar or a grand rounds presentation or something formal. Now, informal learning I think happens every day because oftentimes, we'll say, "Hey, did you read this article? Did you see this? This came out, that came out. What do you think of this?" So I would say there's both formal learning opportunities and informal. (Charlotte)

> I think professional learning probably happens all the time and I don't think it's always as formal… I think that's why I'm having trouble thinking of examples - I don't view it in a very formal way, but I think it's probably happening on a very regular basis. (Margarette)

Formal and informal learning strategies were found to complement each other on several levels. Certainly, with respect to frequency (as described by participants above), formal learning was perceived to occur infrequently whereas informal learning was felt to be a constant experience. This had implications for access to resources matching learning needs, as explored below – formal learning was viewed as more limited in terms of providing timely access to necessary resources. Alternatively, the scope of learning resulting from formal and informal means varied:

> When things come up in your day-to-day work repeatedly, you realize that you may have a need for something bigger. You recognize a gap in your learning. And I think you start looking for those opportunities for formal learning. I feel like the formal learning really lays that foundation. It's a little bit more solid than the things that you're just learning on the fly, so that you can plug it into whatever you're needing to accomplish. I feel like, in the day-to-day, sometimes we just get the puzzle pieces one at a time, but with a formal learning opportunity, you get the big picture or the framework. (Betsy)

This interviewee suggested that insights gleaned from formal and informal learning were complementary in terms of robustness as formal learning constructed the framework and informal learning, the design details.

Action

Argyris and Schon (1974) stated that "each situation of practice is an opportunity for testing some elements of theory of action. Acting is testing, and the practitioner is an experimenter" (Argyris & Schon, 1974, p. 159). Genetic counselors were indeed experimenters as they performed active testing by new knowledge, techniques, and tools for practice, as a means of accomplishing "continual interweaving of thinking and doing" (Schon, 1983, p. 280): "just jumping in and learning by making mistakes and being undaunted by the challenge" (CIQ 38), "I learn best by using the knowledge directly with patients so the more opportunities I had for hands on interaction with patients, the more my understanding grew" (CIQ 90).

Genetic counselors actively fashioned unfamiliar information by iteratively interpreting and applying it to interactions with patients. Some first practiced independently as preparation:

> I got a positive test result in something that I just haven't dealt with in a while, so before I go through calling the patient, it's just me practicing, making sure that while I know this information and these cancer risks in my head, that I can be able to explain it to the patient in a way that makes sense. (Lydia)

Once assured of comfort and confidence with the information, participants described actively honing explanations through repeated interactions with patients: "it was completely experiential – I tried different approaches to organizing my sessions and my prep/follow-up" (CIQ 105) and "I would often try to refine my practice of counseling WES with repetition and consciously trying to critique my practice to make it better in the future" (CIQ 256). Actions during patient encounters were coupled with careful reflection of those actions and their impact.

Participants also described testing their knowledge by writing personal guidelines or templates: "writing sample dictation paragraphs describing the new testing allowed me to solidify a simple accurate explanation" (CIQ 40), or tools for practice such as the creation of new visual aids in the form of a "flipbook":

> Most of my strategies came from simply trial and error with patients. I'd come up with a new flipbook, head into a session, and realize that it either didn't work at all or confused the patients or made them too uncomfortable with next gen testing that they were all choosing to just pursue BRCA. So then I'd change the flipbook and do it all over again. That was the most helpful for me and to this day I'm still changing that ruddy thing every couple of months. (CIQ 104)

The above descriptions of experimentation demonstrated "the probing, playful activity by which we get a feel for things. It succeeds when it leads to the discovery of something there" (Schon, 1983, p. 145). These action-oriented learning through application hinted at elements of Schon's (1983) theory of reflection-in-action as participants described making constant adjustments when experimenting, yet such insights were relayed in retrospect and as reflection-on-action and not directly observed. As an active expression of reflection, experimentation was conducted behaviorally and through interaction with contextual factors such as other individuals (patients or colleagues) or artifacts (by creating tools for practice). There was some evidence in the genetic counseling literature that genetic counselors might procure opportunities for similarly active learning through peer supervision groups, as described by Dunlop et al. (2011).

Education

Literature on professional development for genetic counselors prioritized participation in formal educational opportunities such as meetings, conferences, and lectures as effective means of maintaining or furthering knowledge and expertise (Miranda, 2012; Scott et al., 1988). Acceptability of education as professional learning was substantiated by the overwhelming margin of formal to informal learning activities as represented in the database of continuing education units. Participants held divergent views on education's influence on their learning. Some viewed conferences as the most efficient way to speedily gather a great deal of information: "attending conference is one of the main ways to get lots of different updates from lots of different specialties in a short two- or three-day timespan" (Lydia). Conferences were felt to facilitate effective learning by removing the professional from competing pressures of daily work and life.

> I think where I learn best or I have the most focus in my learning is at a conference… trying to deal with day-to-day learning between clinical and administrative responsibilities, I feel like I'm just shoving it in and I'm not spending the time to really ponder and look at it. When I do, I feel guilty for doing so because I'm not doing something else that needs to get done. (Caroline)

> Going to a conference is great, there's an atmosphere of excitement and learning that you get when you're there in person. And I think there's no substitute for that face-to-face learning experience as well as the discussions that happen around that among other people who are attending. (Betsy)

Conferences were received as time protected for learning and deeply engaging with colleagues specifically around learning and education. While an opportunity to reflect on one's learning in this way was appreciated, participants shared concerns expressed in the literature (Dirkx et al., 2004; Mott, 2000; Webster-Wright, 2009) that information and knowledge relayed by educational events were rendered quickly obsolete in swiftly changing fields.

> I am not a big fan of the annual conference. I don't ever feel like it's cutting edge enough… the abstract has to be submitted so far in advance that by the time you get to the meeting, the talks are totally out of touch, like "Yeah, I already knew that… I knew that six months ago." Well, that's because you submitted your idea for a talk ten months ago… I don't feel like it's keeping up with the rapid pace of changes and learning in genetics. (Charlotte)

While conferences were widely accepted as a mechanism for efficiently absorbing copious amounts of information, the lasting impact was limited by discrepancy between frequency of educational events and rapidity of change in the information being conveyed through the education.

Access

Genetic counselors responded quickly to realizations that learning was needed. They showed resourcefulness and alacrity in designing learning processes to include permeable, complementary, active strategies. Participants often remarked on the importance of having access to preferred or efficacious resources to support their learning. Their comments construed access as availability and timeliness. As reading and discussing were central strategies, participants stipulated the requirement of having access to corresponding resources of information and colleagues. In order to read, genetic counselors needed to obtain pertinent information from the professional literature.

> A very practical thing that supports me is being in an academic institution where we pretty much have access to any article, anything we want. I worked at a hospital that didn't have that, and you don't know how great that access is until you don't have it… (Louisa)

Having access to information in the literature – considered robust and reliable – aided genetic counselors in reading, interpreting, and applying information to their learning. Likewise, speaking with experts or colleagues was predicated on being able to reach out to them:

> I'd say that a challenge I have now is because I work from home and work in the field, I'm not necessarily seeing my colleagues on a daily basis in the office. So whereas before, when I worked clinically, I'd see the other genetic counselor every day and if I had a question, just in our day-to day interaction, I could easily run the question by someone. (Darcy)

Access, as framed by this interviewee, was in part about availability and also about ease; when a typical work day included interactions with colleagues, learning could be swiftly integrated without much additional energy or planning. Humorously, another interviewee hinted at the importance of proximity while also suggesting that availability was a matter of others' openness to exchange: "maybe the expert's not accessible because they're too cool, or maybe they live in Guam" (Henrietta). Beyond the spatial, proximity was invoked as a spatial as a timebound characteristic:

> Part of maybe why I rely on that so much is that it's available – it's immediately available. Conferences and taking courses and webinars, those are great and I do try to jump on them when they're available, but when you need an answer today… In order to help a clinician and a patient, you go to your immediate resources... They're right here and I need the information now. (Betsy)

Participants connected strategies with corresponding resources to which they needed access – via availability and timeliness – in order to fulfill their preferences and plans for learning.

What Roles Do Colleagues Play in the Professional Learning of Genetic Counselors?

Genetic counselors showed clear preference for colleagues as the others with whom they learned. They defined colleagues in an inclusive way: coworkers, former classmates, genetic counselors in similar specialties or at the same institution, genetic counselors working locally or interacting nationally through special interest groups or listservs, physician colleagues, and genetic counselors working at testing laboratories. Wenger

(2000) explained that an individual participated in constellations of communities of practice, layers of communities with various degrees of overlap in membership, joint enterprise, shared repertoire, and mutuality. These overlapping constellations were found to be a useful construct for imagining the multiple sets of colleagues with whom genetic counselors enacted professional learning.

Interestingly, criteria for acceptance of a colleague as a learning partner varied somewhat between the critical incident questionnaire and interview data sets. Cognitive criteria in the form of assumed professional opinion or expertise was used to identify learning partners by those submitting critical incident questionnaires. While interviews confirmed expertise as an important cognitive criterion for learning partners, they also emphasized the significance of relational criteria such as personal connection or affinity, trust, and familiarity. Additionally, they invoked contextual criteria by suggesting that choice of learning partner was dependent on the topic. These additional criteria connected to model II theory-in-use (Argyris & Schon, 1974) via focus on learning process rather than outcome and were taken as evidence of progression toward a more holistic approach to learning consistent with the enactivist perspective of experiential learning:

> Interactivity places emphasis on experience in relationship with the environment; intra-personal, interpersonal and social. This environment is complex and ever changing and it is the relationship between the continuity of experience and the interactivity with these dynamic changing environments that is the catalysis for creativity and innovation. (Nicolaides & Yorks, 2008, p. 52)

When cognitive, relational, and contextual criteria were utilized to identify colleagues as learning partners and invite them into mutual exchange and interactivity, genetic counselors were honoring the inherent complexity of the practice challenges facing them. Their responsiveness and adaptation to others and contextual elements was promising given that in "adapting to changing membership and changing circumstance, evolving communities-of-practice are significant sites of innovating" (Brown & Duguid, 1991, p. 41). The promise of innovative learning outcomes from collaborating with colleagues was viewed as a promising response to genomic technologies.

Genetic counselors included colleagues in their learning through different forms of interaction (discussions, consultations, problem-solving, cooperation) with different people (colleagues, other genetics professionals, interdisciplinary groups) for various purposes (to share opinions, gather alternative perspectives, pool experiences) to different outcomes (new knowledge, novel approaches, new insights, verification). Genetic counselors sought out others as learning partners, frequently and with zest. The extensive influence of colleagues for professional learning was seen as evidence of the idea that colleagues represented a powerful social component of the context in which genetic counselors worked and learned (Dirkx et al., 2004; Webster-Wright, 2009). Interactivity – particularly at the edges of participants' expertise – and interdisciplinarity were identified as essential characteristics of the role of colleagues in genetic counselors' professional learning.

Interactivity

Support for interactivity was present in all three data sets of this study. The critical incident questionnaires highlighted how genetic counselors sought out colleagues for their expertise, knowledge, and opinions related to the learning need at hand – often an innovation or new technology. The interviews added that genetic counselors engaged colleagues in discussion to learn of their experiences with similar challenges or in analogous scenarios, in some cases acknowledging the inherent limitations of one professional's capacity to learn and navigate ambiguous circumstances. And the database of continuing education unit credits contained a category – professional activity credits – which encouraged several avenues to contributing one's own experiences and opinions to the community as well as learning from those of others.

Community of practice as defined by Wenger (1998) "are groups of people who share a concern or a passion for something they do and learn how to do it better as they interact regularly" (Wenger, 1998, p. 1). Communities of practice are distinguished by three essential elements: joint enterprise, shared repertoire, and mutuality. Genetic counselors in this study certainly had a joint enterprise – the quality care of individuals and families affected by or at risk for conditions with genetic or genomic contributions – though they may have each contributed to this enterprise in unique ways or from different angles depending on their specialty. This was prominently displayed through declarations of patient care as motivation for learning. They also enjoyed a shared repertoire of knowledge, skills, and attitudes, established through a standardized training model and maintained through professional organizations, social exchanges among colleagues, and professional learning. Mutuality was demonstrated through discussion as together genetic counselors furthered the joint enterprise and drew from the shared repertoire. The framework of community of practice therefore informed the portion of genetic counselor's learning which was social in nature and, by exchange with others, contextualized.

Genetic counselors described interactions with colleagues as gaining access to others' experiences and professional opinions, comparable to examples from the medical literature of community of practice supporting learning and exchange of ideas among healthcare professionals (Ranmuthugala et al., 2011). Others' experiences were combined to one's personal knowledge stores through a kind of pooling thought process by which experiences and perspectives were melded together, generating a shared repertoire from which to draw insight in future occurrences.

> An example would just be being exposed to other genetic syndromes or things that maybe I haven't come across myself, but being as that there's five of us here, again, we're able to see a wider breadth of things which is kind of keeping myself to date on the screening recommendations or things of these more rare syndromes that my colleagues may have seen that I haven't yet. (Lydia)

Cervero (1988) characterized this type of pool as a store of practical knowledge consisting of "examples, metaphors, images, practical principles, scenarios, or rules of thumb that have been developed primarily through prior experience" (Cervero, 1988, p. 55). Like any repertoire, the constructed pool constituted a collection of eclectic items which could be reviewed and utilized in future scenarios demonstrating analogy to past experiences.

> My colleagues and I worked together. We divided up the list of new genes, individually performed literature searches, and then met as a group to present a summary of our research. We discussed cases and unusual results together as a group. We continue to evaluate new consensus guidelines regarding recommendations for testing, and management recommendations based on results. We attend conferences to learn about cutting-edge research involving newer genes on these cancer panels, and then meet as a group to discuss what we have learned from outside conferences. (CIQ 84)

Here the participant explained the shared repertoire as crafted with knowledge-based components garnered from collaborative research and interpretation of the literature, practice-based components of analysis of clinical cases, strategic components of assessment of alignment with general guidelines and standards, and educational components of assimilating formal education. The individual's openness and acceptance of others' contributions was noted to be like descriptions of the non-defensive learner in Argyris and Schon's (1974) model II theory-in-use, similar to how one interviewee described inviting external contributions.

> Others might have a different progression of thoughts and that might lead them to a different primary conclusion, secondary conclusion, in that problem-solving process. So I rely on them because it's essentially giving me a back-up brain, a different way of thinking about the problem so I have two trains of thought or three trains of thought happening independently to solve the same problem. (Caroline)

Interacting with others around a shared repertoire was seen as a way of enacting mutuality, the third component of community of practice as defined by Wenger (1998), identified as engagement with others in coordinated efforts of learning.

As Pereles et al. (2002) noted in their study of physicians' communities of practice, mutuality was accomplished through dialogue. There was no shortage of support for discussion and dialogue as learning strategies among genetic counselors. Cervero was read as supporting expression of interpretations of knowledge when he stated, "[p]ractical knowledge must be justified on the basis of public criteria rather than private ones" (Cervero, 1988, p. 56). Genetic counselors used discussion and dialogue to expose their thinking to others, who could then interact with them to interpret and apply further reflections.

> It's a directed reach out to colleagues who I feel have the appropriate expertise and experience to guide me further. And then having spoken with them and reached some kind of consensus or conclusion about what's next, then I would take that information and go lateral and down or up if needed as far as dispersing and implementing it (Elinor)

Genetic counselors' inclination toward interaction – seen in various forms as analogous to joint enterprise, shared repertoire, and mutuality – was counterbalanced, and perhaps subtly reinforced – by discomfort with circumstances of isolated practice, here understood as practice in the absence of colleagues, formal guidelines, relevant information, or standards of practice. As noted in the genetic counseling literature, the absence of alternate perspectives – and the uncertainty such a void created (Bower et al., 2002) – was perceived as a potential contributor to the strong motivation genetic counselors displayed for interacting with others. Participants remarked that, given the cutting-edge nature of the profession, "getting published data can sometimes take a while, getting robust enough Ns and those type of things, so just hearing about people's experiences" (Louisa), interacting with others, became a necessary alternative. Concurringly,

> If it's a really well-defined thing that I can easily get all the information that I need on the internet, like FAP, then I don't really reach out [to colleagues]. But anything like… I don't know, this BAP1 [or] DICER1… I reached out about things like that. (Kitty)

While an initial effort went into identifying resources independently, once at the edges of current knowledge or standard of care, genetic counselors turned to others for insight and affirmation on how to approach situations with no precedent. This was especially evident in the context of clinical research, in which genetic counselors were accustomed to a lack of external information as they were engaged in the process of generating new information themselves:

> We have a pretty darn interactive team, so most of the time, when I have a specific question or I'm aware that I need to learn something, I go ask a person typically rather than look in the literature. I kind of go there second, because, if it's a disease-related question, there's a good chance that some of my colleagues may already know the answer. (Margarette)

Interdisciplinarity

Though interactions with colleagues were deemed universally facilitative of learning, participants particularly singled out interactions with people from other disciplines as uniquely impactful. Inclination toward interdisciplinarity was invoked in the literature when Zahm (2009) and Miranda (2009) drew from the other professions (especially psychotherapy) to explore the professional development and expertise of genetic counselors. Additionally, genetic counselors' values were proposed to be remarkably similar to those of mental health professionals (Pirzadeh et al., 2007). However, in those instances, the framework of one discipline was applied to another rather than being allowed to mutually infuse one another to produce hybrid insights, as was the case for accounts related by participants as they emphasized intermingling, synergistic interdisciplinary interactions. Interviewees strongly supported interdisciplinarity as a strategy for professional learning, encouraging genetic counselors to "escape the genetics bubble" (Charlotte) of genetic counseling expertise and looked to learn with professionals from different fields. The alternative perspectives commingled through interdisciplinarity allowed genetic counselors to see their work in expanded context and from different angles.

> Being exposed to and part of a team with so many different areas of expertise represented is really, really helpful and I think it allows me to kind of put genetic counseling in this broader context of the work that can be done, so it's not just kind of this silo of consenting patients and returning results. I'm seeing all of the behind-the-scenes work and finding ways that we can participate in that as a genetic counseling team as well. (Lizzie)

> It's the same specimen that just walked into the lab for chromosome analysis, but we will all look at that as something else. The sales person views it as, "Oh, is this a direct result of my selling technique?" The billing person will say, "Is this a Medicaid patient, cash patient, or private insurance patient?" The accessioner will say, "Is this a green top tube, purple top tube, do I need to refrigerate it, what am I going to accession it for?" So, I just listen to other mechanisms… They're all looking at the same thing but will define it in completely different terms! (Mariah)

Interdisciplinary interactions were perceived as enhancing, expanding, and invigorating learning by bringing individuals with diverse perspectives into conversation and engagement with one another. Cervero noted the benefits of cross-discipline engagement in continuing professional education when he stated, "the study of similarities across the professions can yield a fresh exchange of ideas, practices, and solutions to common problems" (Cervero, 1988, p. 15). In addition to placing one's learning in context and combining different lenses on the same topic, interdisciplinarity was noted to strengthen problem-solving processes:

> You have tunnel vision once you get into these specialties or rare disease specialties. The more specialized you get, the more tunnel vision you get and you forget the big picture. So when you get all of those people with tunnel vision in one room, suddenly you have a much bigger picture… We go to a weekly multidisciplinary conference where we talk about patients that we're seeing in our clinic who are going to need ongoing medical care later in their life by different specialties. So all these specialties get in the room and we always go way over our time because one expert will say, "Well here's how I weigh in and here's how I approach it," and the whole rest of the room is fascinated, "I never thought of that. I didn't realize that was an issue. Oh my gosh, I've never really learned about that – can you tell us about it." So everyone loves going to that conference, because you get to learn something, not just by somebody lecturing to you and you taking notes, not just by reading journal articles or looking at things online. You actually get to have this face-to-face conversation where you can say, "Wait, wait, wait – slow down. I don't understand this," or "I don't understand that." That back-and-forth learning process is very fulfilling. You actually walk out excited about what you learned instead of like, "I don't know – I read something today – I don't really understand what it meant…" (Charlotte)

Interdisciplinary was therefore considered an enhancement to interactivity, a way of challenging one's reflections by setting alternative perspectives to interact, resulting in learning that was more contextualized, nuanced, comprehensive, and memorable.

How Do Specialization and Years of Experience Influence Selection of Strategies?

Professional learning was noted to be markedly enhanced by the diversity introduced through interaction with others who brought unique slants of alternative perspectives, ranging opinions, past experiences, different disciplines. This raised the question as to whether variability of factors external to genetic counselors – in the form of interactivity and interdisciplinarity of colleagues involved in their learning processes – would be matched in terms of vigor and vibrancy to factors internal to genetic counselors, namely specialty and years of experience. This line of investigation was viewed as compatible with prior express curiosity about "possible differences in professional development due to experience, specialty area, amount/type of post-degree supervision, and other characteristics" (Runyon et al., 2010, p. 384); though interest had previously been mentioned, inquiry aimed at answering such questions was not found in prior literature.

Specialty – Clinical and Non-Clinical

Rom (2006) described specialization within genetic counseling as a response to increasing informational demands of practice, making it more challenging to maintain expertise is multiple areas of practice; complexity of practice constrained learning such that specialization was a path to making learning and practice manageable. While some differences were expected among clinical specialties, a greater discrepancy in learning and practice was posited between clinical specialties – reproductive, cancer, and pediatric genetic counseling – and non-clinical specialties – research, industry, and education, among others even more emergent. Analysis of potential influence of specialty on professional learning was therefore explored in terms of a clinical/non-clinical dichotomy, with acknowledgement that such a split was somewhat arbitrary and artificial as many roles contain responsibilities which would cross over the divide.

Clinical genetic counselors were found to be more likely to identify a constant press to learn. In responding to the demand, they were more likely to seek structured learning activities and draw on networks as learning strategies. The established, somewhat traditional quality to these learning strategies harkened back to Cervero's (1988) functionalist viewpoint of professions which corresponded to professional learning focused on information and content. Though clinical genetic counselors noted increased complexity and ambiguity in their practice setting, these espoused learning strategies were aimed at straightforward solutions to graspable problems. Analogy to Schon's (1983) technical rationality was also suggested by the crisp linearity between need and solution.

In contrast, non-clinical genetic counselors were more likely to convey awareness of the messiness and confusion of their practice context through their choices of learning strategies which honored complexity and acknowledged ambiguity - "situations of uncertainty, instability, uniqueness, and value conflict" (Schon, 1983, p. 50). They claimed interdiscipinarity as vital to their learning, and specified a lack of applicable, relevant resources as a challenge. This indicated non-clinical counselors were operating at the edges of practice and choosing their learning strategies to reflect the absence of established procedures for practice or learning. This embrace of complexity and ambiguity was viewed as illustration of Cervero's (1988) critical viewpoint of professions and its analogy to Schon's reflection-in-action, both for their attention to flux and uncertainty in context – "indeterminate zones of practice" – and subsequent requirement that professionals actively engage in shaping their learning rather than travel established learning procedures. Learning in the critical viewpoint is accomplished through practice (Cervero, 1988) and was formulated through "experience, trial and error, intuition, and muddling thought" (Schon, 1983, p. 43).

The differential patterns of learning between clinical and non-clinical genetic counselors was understood through comparison of their relative contexts, with clinical roles relatively more well established and non-clinical roles in the process of emerging. This corresponded to contrasting levels of complexity and ambiguity in roles and context, which then was believed to shape learning preferences: more familiar clinical roles and contexts were perceived as less complex or ambiguous and therefore learning could be more structured, whereas emerging roles were more complex and ambiguous such that learning had to be actively monitored and modified in a manner akin to reflection-in-action.

Years of Experience – Novice and Expert

Notice of variation among genetic counselors with a range of years of experience was paid during analysis of professional learning strategies. Those with fewer years of experience relied heavily on others via networking, particularly to buttress their inexperience with other's experiences and expertise. Conversely, experienced genetic counselors increasingly depended on reflection, imbued with other's alternative – and often interdisciplinary – perspectives. Interestingly, the inflection point of comparison among patterns of learning was at 15 years of experience; genetic counselors with up to 14 years of experience expressed learning strategies more similar to each other than to those with 15 or more years of experience.

The above trends mirrored mentions of years of experience as a variable potentially differentiating genetic counselors approach to practice and learning (Resta, 2002, Runyon et al., 2010; Zahm et al., 2016). Resta (2002) formulated a schema of progression through a genetic counseling career from early focus on knowledge acquisition, through growing confidence, ultimately to refinement of psychosocial counseling skills (Resta, 2002). The finding of this study that those in the first half of their career feel compelled to augment their experiences with those of others aligned with Resta's supposition of knowledge as a foremost concern. Speculation about growing confidence was also seem as a potential explanation for genetic counselors with more experience depending more on internal capacity for reflection, as confidence in one's assemblage of past experiences – and presumably successes – would support a genetic counselor in relying on internal reflections rather than running to others for external input.

Though differences in learning were noted between less and more experienced counselors, there was by far more similarity of strategies across both categories in the form of reading and discussing. As "genetic counselors from all experience levels variously mentioned optimism and pessimistic uncertainty about the future evolution of genetic counselors' roles and jobs" (Zahm et al., 2016, p. 828), it was viewed as unsurprising that learning should be somewhat consistent given the shared context and reaction to that context assumed to be shared by all.

How Does Ambiguity Tolerance Influence Selection of Strategies?

Ambiguity tolerance (AT), as the reader may recall, was included in analysis of professional learning as a trait reflecting "a range, from rejection to attraction, of reactions to stimuli perceived as unfamiliar, complex, dynamically uncertain, or subject to multiple conflicting interpretations" (McLain, 1993, p. 184). This characterization of response of complexity and uncertainty seemed to correspond to Argyris and Schon's (1974) portrayal of possible responses to changing contexts: one either became "progressively less able to tolerate frustration, less able therefore to generate nonroutine behavior, and more hemmed in by his own defenses" or oppositely "increasingly able to tolerate more frustration, create more opportunities for challenge in this environment, and push back the boundaries of defense mechanisms over which he has no control" (Argyris & Schon, 1974, p. 89). The distinction between favorable, functional responses to ambiguity, complexity, and uncertainty and maladaptive reactions – and the availability of a measure to quantify position on a range between polarities – was useful in exploring genetic counselors learning in response to complex change which implied increased ambiguity and uncertainty.

Ambiguity tolerance appeared to influence preferences for several aspects of professional learning. Those with lower ambiguity tolerance preferred familiar learning strategies which they then also encouraged other to do by suggesting they take advantage of learning opportunities readily available; they were also particularly confused and displeased with questions about what they would do in absence of their preferred learning strategies. That these participants would be drawn to familiar, existing learning opportunities was considered consistent with expected lack of comfort with unfamiliar or new elements and was deemed associated with Argyris and Schon's (1974) characterization of those whose learning was restricted and potentially compromised by intolerance for complex change of the kind expected by the advent of genomic innovations. On the contrary, participants with higher tolerance for ambiguity showed predilection for combining perspectives and past experiences with colleagues and jumping into learning opportunities beyond the genetic counseling arena. Genetic counselors with higher ambiguity tolerance were logically undaunted by new experiences and open to informal sources of information in the form of colleagues' narratives over structured activity. This was found to be in harmony with Argyris and Schon's (1974) picture of individuals who gave themselves over to complex and uncertain circumstances and, rather than attempt to control factors and processes, were open to those naturally occurred and fluxing in the environment.

While the above analysis was focused on ambiguity tolerance, several other insights were gathered by consideration of the conceptual connections between ambiguity, uncertainty, and complexity, as clarified by Han et al. (2011). In their thinking, ambiguity and complexity were sources of the broader phenomenon of uncertainty; ambiguity produced uncertainty through its ilk of incomplete or confusing information, while complexity did so through its manner of multiple meanings. Participants expressed astute awareness of both uncertainty and complexity as features of their practice and professional context.

Uncertainty

Uncertainty, as the concept encompassing ambiguity and complexity, was explained as “self-awareness of incomplete knowledge” (Han et al., 2011, p. 830). Uncertainty was frequently mentioned in the genetic counseling literature – as a common challenge arising in practice (Bower et al., 2002; Groepper et al., 2015) and as a reaction to some genomic testing results which complicated patient encounters (Bernhardt et al., 2014) – as one participant put it, a sense of feeling “scared about the large possibility of challenging-to-interpret results and the ‘can of worms’ that we may unleash” (CIQ 62). Concerns about uncertainty of genomic technologies were prevalent throughout the critical incident questionnaires, whereas uncertainty related to practice was evident in the interviews. However, in rare instances, genomics was argued to reduce uncertainty: “with panels you don't have to do as much ‘thinking’ about which test to order, which is most appropriate, and which is most cost effective” (CIQ 21). Importantly, Werner-Lim et al. (2016), in their article on recommendations for counseling about microarray results, suggested it would be useful to assess genetic counselors’ tolerances for uncertain information (Werner-Lim et al., 2016), a fascination which paralleled interest in assessing ambiguity tolerance in the present study.

As uncertainty was constituted by awareness of incomplete information, information-seeking skills were found to reduce uncertain concerns. “I learned how to research and stay up-to-date to ensure I'm appropriately informed, and now I am much more comfortable with the uncertainty” (CIQ 13). Learning was one approach to reducing uncertainty; another was cultivating acceptance – building increased tolerance – for uncertainty inherent in practice:

> I sort of accepted early on that being a genetic counselor is learning how to learn as opposed to memorizing everything, so I never got too fearful about not knowing a particular fact aside form board preparation, because I feel as though my education provided me with a lot of experience and tool and opportunity to learn how to learn. Learn how to research and become comfortable with what you don’t know. (Caroline)

This interviewee married information-seeking and acceptance as her response to uncertainty. Another displayed unqualified acceptance as she normalized the presence of uncertainty in her work:

> [I] realized over time that we as counselors discuss uncertainty all the time... Uncertainty is the only thing we are certain of. This was the major shift in my mentality and therefore approach to genetic counseling - thus being able to provide a more confident approach to patients. (CIQ 45)

Acceptance instilled confidence and removed reluctance:

> I'd say just the willingness to accept it was the most helpful. Once I stopped hemming and hawing about whether to do the panels or not and to just start offering them, I found it to be a lot easier than I'd feared it would be. I spent so much time worrying about it that I was making it seem more difficult and complicated than it actually was. Once I just accepted that I'd see it through no matter what, it came a lot easier to me. (CIQ 104)

Genetic counselors were, at times, aware of their own agency in creating feelings of discomfort or fear in the face of uncertainty and used this awareness to convert uncertainty to acceptance. Tolerance for uncertainty, acknowledged in oneself, was in some instances extended as trust that clients could manage uncertainty as well: “I've become more confident in my clients' abilities to understand and consent to complicated testing, including the idea of consenting to the fact that test results may have an uncertain outcome" (CIQ 68). Tolerance for uncertainty as a trait attending technologies, practice, professionals' competence, and patients' perceptions was noted throughout the literature and participants' responses, validating concern for its effect on genetic counselors' learning.

Lack of Learning Resources

Participants' tolerance for uncertainty was found to be associated with the extent of availability of and access to resources which could provide information to cure the perceived deficiency of knowledge. Deficit of these resources was viewed as a primary barrier to learning: "lack of information about a lot of the questions that I want answered. You can't make it up, and a lot of this stuff is so new that the information just doesn't exist" (Louisa). Many participants felt stymied by a lack of information regarding interpretation of genomic testing results ("for which there are ill-defined cancer risks and a dearth of management recommendations" [CIQ 84]) and no established or standard guidelines for clinical practice ("lack of established guidelines for when to test, how to test, and how to manage both positive and negative individuals… frustrating to not always know how we can best use that information to benefit the patient" [CIQ 321]).

> One of the big challenges is that the level of learning that I'm doing now is beyond… there's no really well-established genetic counselor practice for some of this genome research. I think the research side of this is different than what research counseling has been in the past; this isn't like a well-established prenatal category or cancer category. I think that's the challenge, that there isn't this existing infrastructure to go to. It's almost like I feel like I have to be charting my own course a little bit, which is a little nerve-racking and there's a lot of uncertainty with that too. (Lizzie)

Again, here was an account of working at the outer reaches of practice – there were no objective standards to facilitate learning. Some were more accommodating for wont of information than others:

> Most importantly is that even after two years there is no protocol. While I am far more comfortable when making these decisions, there still is no algorithm to follow. And that's okay. Overall it taught me as a profession the role of clinical discretion in patient care. (CIQ 251)

This sentiment was consistent with statements above in which genetic counselors described accepting uncertainty, though in this case, with residual emphasis that information remains scarce or nonexistent.

Recalling that genetic counselors relied on reading and discussing as core professional knowledge strategies explained consistency of frustration when colleagues were as nonexistent as relevant information.

> I also find that somewhat challenging for me as a genetic counselor in research, because there's not a ton of us out there, and so if I ever want to find a mentor or somebody to talk to that is doing something very similar to me, it's more of a challenge than finding somebody who's doing something wildly different than me that I could take small lessons from, but it would be beneficial to have somebody similar to me that I could big lessons from. (Marianne)

In the absence of others with similar expertise, in the form of a person or as published guidelines or standards of practice, genetic counselors were placed in an unenviable position of being aware of uncertainty yet unable to cure it with typical and preferred learning strategies.

Outcomes of Professional Learning of Genetic Counselors

Genetic counselors utilized professional learning to pursue and maintain competence in a rapidly evolving profession, even as that benchmark remained in constant motion due to innovations and inherently complex, evolving practice. They owned and implemented many strategies that were permeable, complementary, and active in ways that illustrated the relationship between learning and the context in which these occurred. They did so independently and collaboratively with colleagues. Professional learning enabled genetic counselors to work toward competent practice – as they themselves and the professional communities defined it (Wenger, 1998) – amidst complexity and demonstrated their commitment to ongoing co-evolution of practice and learning, of their work and selves. They brought the full force of their reflection and interactions with others to bear on these circumstances of learning and, in some cases, appeared to achieve systems-level appreciation for the immensity of their task and efforts to accomplish it: “once again, we don't know as much as we thought we did. Interpret with caution. I find that the lessons are cyclical, not really new” (CIQ 246). By reflecting, reading, researching, discussing, experimenting, and engaging in education, genetic counselors brought about the scenario below described by Argyris and Schon (1974), thereby demonstrating their abilities to learn and practice in novel, complex, ambiguous, and uncertain environments.

> Whatever *competence* means today, we can be sure its meaning will have changed by tomorrow. The foundation for future professional competence seems to be the capacity to learn how to learn (Schein, 1972). This requires developing one’s own continuing theory of practice under real-time conditions. It means that the professional must learn to develop microtheories of action that, when organized into a pattern, represent an effective theory of practice. The professional must also be able to act according to this microtheories of action and reflect on his actions, relating them to the governing variables implicit in his behavior and determining the impact of his behavior on the behavioral world (on himself, the clients, the client system), on learning (especially on double-loop learning), and on effectiveness. (Argyris & Schon, 1974, p. 157)

Argyris and Schon suggested learning required continually examining and refining, actively constructing one’s approach to practice in concert with enacting that theory through practice. This carried with it a requirement to engage in reflection prior to and during practice so that actions might be internally consistent with intentions and linked externally to intended outcomes. Genetic counselors intimated they reflected in this way: “realizing that we needed to come up with a new style, instead of trying to cram the new tests into our old schedules/formats” (CIQ 336) and “my practice became more transparent and flexible. Not every test or counseling ‘plan’ is right for everyone. I learned that genetics will always be changing and so will my counseling style” (CIQ 260). When accomplished, the conclusion was a perpetual, dynamic state of reflection.

Schon (1983) suggested that deep reflection on the part of the professional would incite a pivot in mindset such that framing of competence would shift from expectations of expertise to openness, honesty, and potential fallibility: “Whereas he is ordinarily expected to keep his expertise private and mysterious, he is now expected to reflect publicly on his knowledge-in-practice, to make himself confrontable by his clients” (Schon, 1983, p. 299). Participants were found to embody the latter mindset:

> It allowed me to be more open with my patients – to discuss the benefits and limitations and explain what other people have done in a similar situation and why they may have done so. I really try to be honest with my patients so I include them in my thought process… Most patients are quite appreciative of my honesty and my transparency. (CIQ 80)

While reflection pervaded genetic counselors’ approach to practice, with some achieving a sense of perpetual change and ongoing development as a distinction of competence, many indicated outcomes of learning that reinforced existing expectations and modes of practicing. A definition of professional development in the genetic counseling literature featured a definitive endpoint to reflection, a conclusion: “an ongoing process with a desired result of competence, confidence, and ‘professionalism’ through both internal (intrapersonal) and external (interpersonal) means" (Zahm, 2009, p. 8). Many participants described outcomes of their learning which were viewed as related to competence and confidence, including confidence in one's ability to communicate effectively with patients and other healthcare providers, and competence to adjust one's practice model.

Confidence While Communicating

Practice studies in genetic counseling have demonstrated a strong focus on relaying information in all models of genetic counseling (Meiser et al., 2008; Roter et al., 2006), hence it was viewed as quite natural that genetic counselors marked the efficacy and thoroughness of their learning by the extent to which it allowed them to feel confident in their communication with patients and colleagues. Confidence was measured by the degrees to which they were able to convey their learned understanding to others, answer questions offhand without reference to resources, and make quality contributions to discussions. Several participants noted a sense of calm preparedness, secure in their knowledge such that they could readily externalize it and share it with others.

> I guess it's just kind of feeling like I have a handle on it, and I wanted to be able to say intelligent things… I wanted to know enough to not sound like a total idiot… I guess it's when I feel like I've reached a comfort level where I can discuss it with other people. (Jane)

> Feeling like I can be an active participant in these discussions and no longer just kind of the questioning, but really participating and contributing my own insights. And then ultimately what I think really helps cement things for me is when I then have to explain it to other people or teach other people. (Lizzie)

Many assessed their confidence by questions asked and answered. When questions arose, they were received as non-threatening and answers flowed easily without needing to confirm one's understanding or double-check informational sources.

> I guess when I don't have any more questions for myself and then that's reaffirmed if I ever have an opportunity to share that information… shared it with my research team and they feel like they don't have any questions, nobody else has any questions, and I've been able to provide a complete picture. (Marianne)

> When you can explain it to someone and you can respond to their follow-up questions… when you don't have to say, "uhhh, I guess I don't really know – let me look that up for you." So how many times does that happen? Actually, if you think about it, it's probably few and far between. (Charlotte)

> When I'm able to talk about it without having to refer back to resources and I'm feeling comfortable with the information and I can convey that to whomever else that needs to be… I truly learned it when I'm able to talk about that efficiently and correctly… once I'm able to have those comfortable conversations with patients and I'm not having to constantly look things up. (Julia)

> When I spoke to the family and I felt like I actually could answer the questions they asked and they were asking really good questions. Some questions I just could answer because I knew that we don't know that information. But most of their questions I could tell them the answer and I didn't feel nervous in the sense that, what if they ask something that I should know and I don't know. I guess just when I talk to them and I realize that they have confidence in me, then I realize I know as much as I can know at this point. (Kitty)

Genetic counselors' learning enabled them to feel self-possessed and natural in their conversations, a confidence reinforced when they sensed that others trusted their input. Participants also noted looking to their patients for clues of their understanding to determine efficacy of their professional learning.

> It's almost a little bit patient-driven, it's a little bit, "Have I gotten them to a point where they can understand what these results are and communicate them with others?", "Have I done my due diligence to make sure they are educated about these results?" (Lucy)

> I think from the guidelines and looking over them, we have that knowledge but it's, "Am I able to explain this to patients in a way that they can understand?" So yeah, it is being able to have an informed discussion with the patient where they really understand the implications of their result. (Lydia)

Participants found it most gratifying that their learning resulted in their improved ability to communicate, which they measured through internal criteria of their own comfort and confidence in relaying information learned as well as external criteria of the number of questions asked and perceived trust and understanding in patients.

Adjustments to Practice

In addition to an expanded sense of competence regarding communication skills, genetic counselors noted adjustments to practice as evidence of successful learning. Adjustments to practice largely fell into two categories: a trend toward more generalized framing of the process and content of the patient encounter. and the creation of policies and procedures. The former was viewed as an example of Argyris and Schon's (1974) model II theory-in-use, due to focus on process rather than outcome: "my counseling has focused more on facilitating decision-making versus pre-test education about specific hereditary cancer syndromes" (CIQ 247) The latter, by comparison, appeared more like model I theory-in-use given inclinations to control and standardize processes and outcomes: "attempting to create new personal policies as a way to create a framework to control a chaotic first few months" (CIQ 38).

Many participants described applying learning toward adjusting their practice so that increasingly complex aspects of practice were made logistically manageable and accessible to patients.

> In the past, when engaging in an informed consent discussion with a client, I was very specific about the gene/condition pair being examined, as well as the outcomes of the test. Now, I find that my discussion is focused around making sure the patient consents to a testing process rather than a particular gene test and a range of possible outcomes. This is especially true when discussing incidental/secondary information from exome sequencing and genes on panels with less clear actionability. (CIQ 68)

This participant navigated the complexity (multiplicity of information produced by new testing) and ambiguity (incomplete understanding of the implications of testing results) by moving away from education of specific information and instead focusing attention – her own and that of the patient – on the process overall. Others took a similar tack: "as genetic testing and methodologies become more complex and vast, I had to take that knowledge and find ways to make it less burdensome or scary for the patient" (CIQ 45).

> We moved from more detailed discussions for single gene disorders to discuss categories of genes in general. Made more general comments then specific. I learned that most patients seem to understand a category system and seem comfortable moving forward with testing of several genes without knowing the specifics of each. (CIQ 11)

In keeping with measurement of communication ability by reference to patient understanding, participants also checked the benefit of adjusted counseling approaches by attending to patients' responses, as well as their own comfort levels. Some found the movement toward generalization quite challenging: "being vague is hard when I am so used to counseling about every possible outcome when we are offering testing for a single gene" (CIQ 37). There was awareness that change was occurring, and for good reason, yet adjusting habits of practice required effort and attention.

Not everyone moved toward a more generalized focus on process; some concentrated on the increased detail of information and embedded it in their counseling and approach to practice: "it's definitely a more in-depth discussion in terms of that, not just in screening recommendations but kind of the science behind it as well" (Lydia). Impulse and action to craft policies, guidelines, and procedures in response to innovative technologies were juxtaposed with the expanding, generalizing bent of the above responses. Policies, as objective standards of appropriate action, were created at several levels. Locally, within groups of coworkers, policies around criteria for implementation of testing were crafted to limit negative outcomes ("we have also made blanket policies that prevent some of these incidental findings, like not offering microdeletion testing except in rare occasions" [CIQ 19]) and protect positive effects ("the practice had to create a policy of how this test was ordered and have all results be analyzed by a genetic counselor so that we did not miss a possible hereditary condition" [CIQ 106]). Need for iterative revision – fluctuation in an artifact designed to be solid – was perceived as vexing: "we had to re-write out NIPT policy constantly as new information came available or lab policies changed. It was very frustrating" (CIQ 227). The impetus to craft structure from within chaos was recalled as national in scope: "the genetic community as a whole has tried to develop guidelines to help clinical genetic counselors interpret whole exome sequencing data" (CIQ 66). These responses to innovative technologies – and the complexity and ambiguity which attended them – was seen as evidence of Schon's technical rationality, a mindset for which "uncertainty is a threat; its admission is a sign of weakness" (Schon, 1983, p. 69).

Interestingly, regardless of whether genetic counselors' learning expanded or contracted the range of behaviors employed in response to changes in the practice environment, ultimately a new steady state was achieved – that of routine: "we now offer NIPT in our practice routinely. I learned that we can rapidly understand an implement a new technology in our department" (CIQ 93). Routine as used in this study implied a new mode of default operation; the quality of that operation varied from standard repetition to continual revision, for indeed some participants were believed to have routinized reflection and adjustment as habits of professional learning.

> I think when it becomes repetitive… when it becomes to the point that it just feels like this is a task I don't have to think about as much. I'm able to go into a little bit more of that muscle memory. That feeling allows me to recognize, "OK, maybe I've skimmed the surface of this and I need to go deeper"… There's a lot of surface area where I can get by and I can do very well at, but at a certain point, when you feel that muscle memory is coming in and that routine, and you recognize there's

> probably some details that I have been ignoring. That's OK for the vast majority of cases, but when we start realizing when I can go a little bit deeper and figure out some of the exception pieces to a process or to knowledge in general. (Henrietta)

This interviewee described a dynamic interplay of comfort and discomfort, confidence and curiosity, which persisted alongside her practice and primed her for perpetual professional learning.

Summary of Professional Learning of Genetic Counselors

Genetic counselors, aware of their environment of practice and alert to emerging innovations, continue in a state of multidimensional reflection through which they constantly identify complex needs, converted to motivations toward learning. Motivations concurrently guide self-direction to choose and implement strategies – permeable, complementary, active strategies to which they maintain access. Colleagues are frequently invited to participate in a fluid and winding process of learning of reading, experimenting, and interacting with others; those with alternative perspectives are particularly prized for the challenge they may pose to existing assumptions. Learning either tends to embrace uncertainty with accommodation – as many in non-clinical roles and with much experience described doing – or to barricade uncertainty through assimilation – as those new to practice or in well-established specialties seemed inclined to do – thereby facilitating or hampering the incorporation of innovations into practice.

Chapter VI

CONCLUSIONS AND RECOMMENDATIONS

Genetic counselors are challenged to remain current in their practices which are performed within contexts of constant, complex change. Innovations in genetic and genomic sciences in particular impart an obligation to sustain competency. Little is known about the professional learning of genetic counselors, overall and in response to innovation. Previous research studied professional development – *what* changed in professionals over time – rather than professional learning – *how* they changed – and generally limited the scope of inquiry to single aspects rather than holistic portrait. This study intended to delve into genetic counselors' experiences of learning related to their work – the strategies invoked, the people involved, the factors influencing, and interactions among these. These were indeed illuminated, as were function of context, inducing motivations, and the allusive sway of uncertainty.

Impressions of professional learning of genetic counselors offered by this study inform ongoing efforts by these professionals to build capacity and competence to operate in a fluctuating practice environment. Stronger and more efficacious learning is expected to enhance performance by facilitating development of professionals toward being more able to navigate complex and uncertain circumstances and are able to support others in doing the same. Additionally, professional learning might promote the application of innovations to clinical care by buoying genetic counselors' abilities to comprehend and handle recent technologies. Finally, bolstered awareness of professional learning as conducted naturally by genetic counselors can be instructive to those who would craft and implement professional education for genetic counselors, healthcare professionals, and any others who find themselves beset by challenges of modern professional practice. To abet these endeavors, exceptional findings from this study are recapitulated below, followed by discussion of implications for future practice and research and the researcher's reflections.

Summary of Outstanding Findings

The following findings are offered as outstanding with respect to understanding the professional learning of genetic counselors. This collection of findings is intended to illustrate the positioning of practice in relation to the professional learning; the importance of reflection, an array of learning strategies, and colleagues as facilitators of learning; and ways in which uncertainty and complexity imprints all aspects of practice and learning.

Practice is an Underrecognized Component of Learning

Formal learning strategies occurring through structured activities superseded informal learning originating and conducted through practice as the learning most readily identified by genetic counselors in this study. Yet upon further consideration, practice-based learning superseded formal learning strategies in terms of frequency and impact. This reveals an intriguing disconnect between consciously recognized learning and subconsciously effective strategies. So nuanced was the difference between learning and practice that one genetic counselor mused as follows:

> That idea becomes a part of your conversation. It's not like, "Oh yeah, and I thought of something extra" but rather "OK, these are the results, these are the three things that we talk about". I think that might honestly be more habit than learning, and I think that's probably a good distinction to make. (Louisa)

Outcomes of learning through practice were so naturally arrived at and employed that it was perceived as habit – learning and practice were merged and, despite this participant's entreaty – indistinguishable, though Runyon et al. (2010) had previously enticed genetic counselors to identify insights into themselves learned through practice as outcomes of professional development. Genetic counselors described being motivated to learn by their patient care responsibilities and viewed practice as a fruitful source and setting of subtle, meaningful learning. Additionally, the professional learning which grew from practice was more readily reapplied to adjusting practice when the learning process was never far from the practice context.

Professional Learning is Predicated on Pervasive and Persistent Reflection

Learning effected in and through practice depended upon reflection, here identified as an intuitive, understated awareness as well as intentional attention. Reflection as a learning strategy had previously been deemed so subtle as to often go unnoticed (Mann et al., 2009), and that was the case for genetic counselors in this study as well. Though nearly all participants took perspective on their learning, describing it in detail, very few took the step of calling this reflection or a reflective process. Still, they described prevalent examples of reflective thinking by taking perspective on their work to unravel complicated or confusing encounters (reflection-on-action, Schon, 1983) and iterative cycles of trial and error (reflection-in-action, Schon, 1983). Similar to the implicitness of learning above, genetic counselors' theory-in-use (Argyris & Schon, 1974) was one of reflective learning – evident in action yet not in account – whereas their espoused theory was of the typical thinking and behavioral actions of their work. In actuality, reflection was aided by information-gathering (reading), alternative perspectives (discussing), and active application (experimenting) – core strategies utilized by genetic counselors for their professional learning.

Genetic Counselors Utilize a Medley of Strategies to Accomplish Learning

Genetic counselors are drawn to the profession by curiosity for genetic and genomic sciences and desire to help people. Reading and researching were revealed as central mechanisms for staying connected to the affinity for science which brought them to this work. Reading served dual purposes of curating up-to-date knowledge and reinvigorating the motivation that comes with fascination. Knowledge was interpreted through personal reflection and discussion with colleagues, who helped refine understanding by comparison and contrast with their own alternative perspectives and past experiences. Reading and discussing were variably combined, proving these strategies to be permeable and compatible with one another. Strategies targeted to information were counterpoised to those of action as participants related learning through experimenting. Reading, discussing, and experiment – permeable, complementary, and active – were encompassed by a reflective stance through which information was absorbed, sorted, and applied.

Genetic Counselors' Learning Depends Significantly on Colleagues

This might seem obvious given the ethos of the field and the profile of a genetic counselor as a helping professional – of course they depend on others when learning. Yet it ran counter to the common values of self-determination and self-sufficiency expressed by genetic counselors in another study (Pirzadeh et al., 2007). The strategies by which genetic counselors engage with others for the purposes of professional learning often assume the appearance of casual interactions, further obscuring colleagues' contributions. It was therefore concurrently surprising and quite natural that colleagues featured as the most significant due to their role as interactive learning partners. It might have been easy enough to acknowledge the role of one colleague by imagining learning in the immediate context of a workgroup; however, it was more difficult for genetic counselors to comprehend and describe the expansive, overlapping, frequently interdisciplinary communities of practice constantly at work within their learning processes, unseen except through instances of affecting conferences, typically separate from the practice setting. This study clarified the extensive reach of colleagues in bringing about professional learning by noting how colleagues were chosen, based on what criteria, and explicated the resulting interactions.

Professional Learning is Complicated by Contextual Uncertainty

Innovations and practice engender uncertainty (a perceived lack of full understanding), via extensive permutations introduced by modern technology (complexity) and conflicting meanings to be made from each and every scenario (ambiguity) (Han et al., 2011). The challenges uncertainty instill are difficult to grasp and still further to negotiate; yet learning and practice are steeped in it. As this study approached innovations, learning, and practice as intertwined and co-evolving (Nicolaides & Yorks, 2008), connection between participants' professional learning and contextual uncertainty became evident. Beginning with initial reactions, through tenor of reflection, execution of learning, and outcomes, participants illustrated bimodal responses to the challenge of uncertainty in the context of their learning and practice. Some expressed frustration with the complexity and uncertainty accompanying innovations and designed to reduce these through familiar mechanisms of learning such as reading and developing policies. Others instead expressed acceptance – even occasionally excitement – and went about learning omnivorously and inviting alternatives so as to adjust thinking and behaviors toward greater versatility without denying or ignoring uncertainty, complexity, and ambiguity surrounding them. Learning outcomes correlate to these respective processes: the former recapitulates established learning without expansion of capacity, whereas the latter maintains an open channel to alternatives, challenges assumptions, and expands competence. These two modes of learning – one assimilating, the other accommodating – represented polarities, not mutual exclusion, and genetic counselors struck a balance between them based on personal capacity, differentially expanded by learning itself.

Implications

Implications for genetic counselors and adult educators' involvement with professional learning were derived from the above findings and analysis. It was noted that all implications applied to both groups.

To Accommodate Innovation, Confront Context During and Through Professional Learning

Genetic counselors would benefit from careful assessment of contextual features surrounding them and their professional learning, including the degree to which uncertainty, complexity, and ambiguity exist and influence them. These characteristics of context – relevant to setting, innovation, and practice itself – posed strong yet rather intangible challenges to participants in this study. Professional learning would be well served by direct analysis of context with focus on these specific traits as they might shape and constrain ongoing reflection and change to yield a more informed and nuanced assessment of learning needs and strategies matched to those needs.

Context has oft been omitted from research on professional development and learning, which instead focused on individual thought processes (Gustafsson & Fagerberg, 2003; Miranda, 2012; Zahm, 2009). However, there has been acknowledgement that learning occurs in and through context (Eraut, 1994; Nicolaides & Yorks, 2008; Schon 1983); such influence suggests that attention to context would enhance learning plans and implementation and bring to light the reciprocal determinism existing between the two.

Genetic counselors could confront context by purposefully making it a focus of reflection when encountering an innovation, assessing changes to the environment, noting new elements and relationships to existing elements, monitoring one's reactions for emotional responses and emerging assumptions – all of which might inform and fortify subsequent strategies to clarify these and supplement personal impressions with alternate information and alternative perspectives. Remembering to reference context throughout professional learning processes would position learning as close to practice as possible, ideally joining them in acknowledged overlay.

Adult educators could confront context by embracing more of an enactivist perspective on reflection, in which context and learner are co-constructed through reflection (Nicolaides & Yorks, 2008), and ensuring attention to context is a central feature of practice-based professional learning endeavors.

Develop Deep and Intentional Reflective Practice

Reflection as attention and awareness of oneself, experiences, and context buttresses professional learning as the mechanism by which learning needs are identified and refined, learning processes are planned, insights are gleaned during learning and put into practice, and learning itself is assessed for efficacy and comprehensiveness. Enhanced reflection fosters more robust professional learning by making each function more rigorous.

The genetic counseling literature references reflection, reflective practice, and self-reflection quite frequently (Abrams & Kessler, 2002; Callanan & Redlinger-Grosse, 2016; McCarthy Veach & LeRoy, 2012; Miranda et al., 2016; Resta, 2002; Runyon et al., 2010; Wells et al., 2016; Zahm et al., 2016), and participants in this study corroborate the extensive reach of its influence on learning and practice. Together, they form a convincing argument in favor of special attention to one's reflective stance and skills.

Genetic counselors could purposefully develop reflective practice by implementing professional learning strategies described in this study: reading literature on reflective practice in the genetic counseling and adult education literature; discussing reflective practice with colleagues, hearing their personal experiences with it, other strategies, perceived benefits; and experimenting with reflection in practice by attending to reactions, circumstantial idiosyncrasies, emerging questions, assumptions, taking note of these, surveying for learning strategies to interrogate them, and monitoring how they compare or contrast, interconnect, and apply.

Adult educators could assist professionals in making systematic improvements to reflective skills by prioritizing professional learning and education activities which build reflective capacity. Though no one method has arisen to accomplish this, it has been shown to be a skillset amenable to improvement through a variety of approaches (Mann et al., 2009). Spotlighting reflection in professional learning and development activities – as content and process, through modeling and skills practice – would assist genetic counselors and other professionals in developing such skills.

Embrace Inclusive and Expansive Definitions of Professional Learning

Both genetic counseling and adult education professionals are encouraged to remain open to critical approaches to learning and education which challenge the assumptions upon which these are based. Possessing inclusive definitions of what constitutes professional learning expands the range of activities considered applicable to novel learning needs and challenges. Such openness to a panoply of opportunities and strategies would yield innovation in learning to match that of practice, at a commensurate rate and in similar scale. Aligning the evolutions of learning, education, and practice would benefit any field which exists in contextual uncertainty, complexity, and ambiguity, including the professions of genetic counseling and adult education.

Literature on professional learning, as noted by Webster-Wright (2009), has focused on formal professional education as the primary means of professional development. Continuing professional education was traditionally framed as a linear transaction in which a learning need is addressed through transfer of relevant knowledge and skill (Cervero, 1988; Mott, 2000); so strong was this system that nearly all professional development offerings in healthcare have been approached in this way (Cervero & Gaines, 2014; Robertson et al., 2003). However, this assumption that professionals' expertise only required update to maintain proficiency of practice – that is, assimilation of new information or skill – has been questioned for its failure to attend to individual, social, and contextual factors (Dirkx et al., 2004; Mott, 2000; Schostak et al., 2010). As a viable alternative, focus has shifted to practice-based models of professional education and learning that prize a more holistic view of professionals learning in connection with each other and context (Eraut, 2012; Webster-Wright, 2009). Such learning is interactive and interconnected, engaging the learner as active participant (Cervero, 1988; Coady, 2015; Daley, 2000; Daley & Mott, 2000), and better suited to complex circumstances of contemporary professional practice.

Genetic counselors can embrace expansive and inclusive definitions of professional learning by following the advice of participants in this study: “never assume that any opportunity isn’t a learning experience” (Elinor); “keep your mind open to educational opportunities that may not look like educational opportunities” (Marianne); “try to apply what I’m learning about something that’s totally unrelated to what I’m doing, and trying to be able to see those connections” (Fanny); “taking advantage of what’s around you, even if it may not seem obvious that it’s relevant to genetic counseling” (Lucy). Questioning assumptions of what constitutes pertinent, appropriate, effective learning has the corresponding effect of broadening the collection of potential learning opportunities. This guidance also hints at being curious, taking advantage, reserving judgment, and actively making personal meaning from any situation. Reflection assists in expanding one’s definition of learning, as does noting the presence of learning in practice and interactions with others. Participants in this study strongly endorsed the value of collaborating with others, especially people from different disciplines, during professional learning. By diversifying the pool of learning strategies, genetic counselors might equalize the import of individual strategies, more easily identify a particular strategy’s strength, and elevate informal strategies to a status equivalent to that of traditional, formal educational events such as conference, coursework, lectures, and presentations. Individual genetic counselors could be supported in shifting these definitions if professional organizations altered requirements related to credentialing to allot equivalent value to practice-based, informal strategies and formal education.

In keeping with the openness advocated above, adult educators could follow the appeals of Eraut (1994) and Webster-Wright (2009) that professional learning be approached holistically. Ironically, expansive definitions of learning may introduce adult educators to uncertainty arising from multiplicity of possibilities (complexity) and conflicting priorities (ambiguity) as present in decision-making on professional learning activities within an inclusive framework. Still, penchants for practice-based, interactive, and social methods implemented continually would likely parallel interest from recipient professionals.

Foster Education Scholarship on Professional Learning of Genetic Counselors

Though this study contributed to understanding of the professional learning of genetic counselors, it was apparent that many aspects of professional learning, education, and development of genetic counselors – and healthcare professionals overall – are still unknown. Both genetic counselors and adult educators should build conceptual and practical bridges to each other to foster education scholarship on professional learning in uncertain, complex, and ambiguous contexts. These efforts would strengthen arguments in favor of the need and importance of ongoing professional learning and provide empiric data to target populations attracted to evidence-based initiatives.

Significant research has been conducted on continuing professional education, with some evidence of increasing attention to practice-based, interactive interventions (Bluestone et al., 2013; Cervero & Gaines, 2014; Robertson et al., 2003), yet the landscape of learning activities warranting study needs extension. Furthermore, existing research utilized measures of professional's performance and clinical outcomes as accepted indicators of effective education. Genetic counselors and adult educations, in expanding their definitions of professional learning, might simultaneously extend the spectrum of potential outcomes by which to assess efficacy of professional learning. Such outcomes should logically correspond to the need or aim of professional learning, not unlike how learning objectives should align with assessment methods. Suggestions for potential lines of inquiry are included in the next section.

Recommendations for Future Research

Understanding of complex phenomena such as professional learning of genetic counselors in response to innovation requires ongoing examination from an array of perspectives. Several suggestions for future research would complement insights yielded by the present study.

Situated Research on Professional Learning

As much of this study's data was offered by self-report, findings and analysis would be complemented by research on professional learning situated in the practice context. This would allow direct observation of professional learning to corroborate or conflict with self-reported impressions, thereby supporting a careful comparison of espoused theories with theories-in-use. It was acknowledged that the methods of this study rested on descriptions of learning practices which necessarily constituted exchange of espoused theories. Study of theories-in-use as conducted in the practice context would allow for assessment of the congruence between espoused theories of professional learning and theories-in-use in practice. Such methodology would be especially useful in elucidating mechanisms of experimentation and interaction with colleagues as central strategies of professional learning in complex contexts. Furthermore, this study was restricted in focus to merely half of the bidirectional relationship between learning and context; situated study of professional learning might allow for exploration of how learning influences context in equal measure and differing ways to how context influences learning. Similarly, technology was seen as influencing practice and learning (Mills & Haga, 2014; Miranda, 2012); perhaps situated study of professional learning might place the researcher in proximity of any instance of practice and learning influencing technology.

Rigorous Study of Practice-based Learning Strategies

This study noted strong connection between professional learning and practice – as initiator, setting, and co-constructor of learning. Additionally, there appears to be growing interest for practice-based learning in the continuing professional education literature (Bluestone et al., 2013; Cervero & Daley, 2016; Cervero & Gaines, 2014; Mott, 2000; Robertson et al., 2003; Webster-Wright, 2009). To be fully embraced by genetic counselors and like-minded professionals and endorsed as valid and valuable learning by professional organizations, practice-based learning must be operationalized and demonstrated to produce specific, concrete outcomes. Research which crafts an evidence base for practice-based learning could be highly supportive of professional learning by demonstrating power and scope of outcomes resulting from these strategies. Staying with the importance of situating research in the practice context, future research on practice-based learning strategies – those strategies which draw from and stay close to the problems and context of practice, including reflection – could provide justification for inclusion of practice-based learning strategies in the list of activities worthy of formal credit toward credentialing.

Holistic Examination of Mindset as a Modifier of Professional Learning

Genetic counseling is surely not the only profession striving to keep pace with cutting-edge science. Future research attempting holistic examination of mindset as a modifier of professional learning among professionals immersed in the complexity, ambiguity, and uncertainty of innovations could yield distinctions of professional learning preferences and strategies that might then support more efficient co-evolution of professionals, professional learning, and practice. Though this study made attempts to identify the influences of complexity, ambiguity, and uncertainty on professional learning, minimal effect was identified among those of differing specialties, years of experience, and ambiguity tolerance. These are but three of numerous potential features or traits of mindset which might modify learning preference and efficacy of learning strategies. Given the current context of practice in many professions, future research on professional learning should include attention to mindset, given the centrality of reflection and growing contextual complexity, ambiguity, and uncertainty.

Researcher Reflections

I have heard that in setting out to do research, you set out to study yourself. In conducting this study, I noted elements of my experiences that prompted this work, yet I was quickly pulled into the narratives of other genetic counselors who loved to learn and committed time, energy, hope, and enthusiasm to improve themselves and their practice through learning. I was inspired by the moxie with which they shared their perspectives; I imagined them as unafraid and relentless in seeking answers and insights, improvements and progress.

Yet, like me, they admitted to struggling to grasp the entirety of context, scope, and implications of the work they were doing. They experienced complexity as both tantalizing and overwhelming and recognized ambiguity as a challenge and a burden. They made progress and mistakes. Yet they pressed on and through, motivated by dedication to the work, to their development as professionals. And to my surprise and gratification, they invited me as a partner in their learning through discussion, pooling their experiences and opinions with mine, interacting with me on the topic of their learning, providing feedback and validation of the work – my work – our work. They became my colleagues and together we reflected and enacted the strategies they described. We joined this joint enterprise, engaged in mutuality, and developed a shared repertoire of ideas and strategies. By doing so, we constellated another community of practice within our working lives.

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Appendix A

Critical Incident Questionnaire

I. Demographic inventory:

1. What is your gender?
    - Female
    - Male
2. What is your age?
3. How many years have you been a genetic counselor?
4. What is your primary specialty area? (Check all that apply)
    - Prenatal/reproductive
    - Cancer
    - Pediatric/general genetics
    - Laboratory
    - Research
    - Other: please specify _______________
5. How long have you worked in your primary specialty area?
6. What is the highest degree you have earned?
    - Masters in genetic counseling or related degree
    - Some post-graduate coursework
    - Doctoral degree: please list area of study ________________
7. In what setting do you work?
    - University medical center
    - Private hospital/medical center
    - Public hospital/medical center
    - Diagnostic lab
    - Private physician's practice
    - Other
8. What is your certification status?
    - I am certified
    - I am board-eligible
    - I am not certified
9. Are you licensed?
    - I am licensed
    - I am not licensed
    - My state does not have licensure
10. In what state or province do you work?

OPTIONAL: If you are willing to be contacted for a follow-up interview about your views on professional learning, please enter your first name and email below. The researcher may then email you in the future to schedule an interview at your convenience.

First name: ________________________________

Email: ____________________________________

II. Critical incident questionnaire:
1. At what point in your career has your approach to your genetic counseling been most impacted by a scientific innovation?
   Describe the situation. What was the innovation? What were you thinking, feeling, or doing at the time? In what ways was your practice affected?
2. How did you learn to adjust your practice?
   What learning strategies did you pursue? What resources did you use? With whom did you consult?
3. What action (if any) did you find most helpful?
   What was the most important step you took? What action did anyone else take?
4. What were the outcomes? How did your practice change? What was the most important information you learned from the process?

III. Ambiguity tolerance assessment: The following is an optional component to this questionnaire. It is an assessment of how someone might perceive and respond to uncertain or ambiguous situations. If you are interested in participating in this component of the study, please respond to each item with a score on a scale of 1 to 7, with 1 being "strongly disagree" to 7 as "strongly agree".
1. I don't tolerate ambiguous situations well.
2. I would rather avoid solving a problem that must be viewed from several different perspectives.
3. I try to avoid situations that are ambiguous.
4. I prefer familiar situations to new ones.
5. Problems that cannot be considered from just one point of view are a little threatening.
6. I avoid situations that are too complicated for me to easily understand.
7. I am tolerant of ambiguous situations.
8. I enjoy tackling problems that are complex enough to be ambiguous.
9. I try to avoid problems that don't seem to have only one "best" solution.
10. I generally prefer novelty over familiarity.
11. I dislike ambiguous situations.
12. I find it hard to make a choice when the outcome is uncertain.
13. I prefer a situation in which there is some ambiguity.

Appendix B

Demographic Information for Critical Incident Questionnaire Respondents

Table 7

Demographic Characteristics of Critical Incident Questionnaire Respondents

	Frequency	Percent	Range
Gender			
Female	110	96.5	
Male	3	2.6	
Prefer not to answer	1	0.9	
Age	Average = 36.6		23-62
Years working as a genetic counselor	Average = 9.7		<1-37
Primary specialty area			
Prenatal	22	19.3	
Cancer	30	26.3	
Pediatric/general genetics	10	8.8	
Multiple clinical	10	8.8	
Laboratory	10	8.8	
Research	6	5.3	
Other	25	21.9	
No answer	1	0.9	
Years in primary specialty	Average = 6.7		0.3-35
Highest degree earned			
Masters in genetic counseling or related degree	109	95.6	
Some post-graduate work	1	0.9	
Doctoral degree	3	2.6	
No answer	1	0.9	
Certification status			
Certified	109	95.6	
Board-eligible	5	4.4	
Not certified	0	0	

Appendix C

Coding Scheme for Critical Incident Questionnaires

Table 8

Critical Incident Questionnaire Coding Scheme

CODING SYSTEM	# coded segments	# total participants	% total participants
	2033	**114**	
TRIGGER (INNOVATION)	**195**	**110**	**0.96**
Genetic/genomic technologies	157	105	0.92
Cardiac predictive testing	1	1	0.01
Chorionic Villus Sampling (CVS)	1	1	0.01
DNA testing (general)	7	7	0.06
Expanded carrier screening	6	6	0.05
Human Genome Project	1	1	0.01
Maternal serum screening	5	5	0.04
Microarray testing	8	8	0.07
Newborn screening	1	1	0.01
Next Generation Sequencing (NGS)	20	20	0.18
Precision medicine	1	1	0.01
Non-Invasive Prenatal Screening/Testing (NIPS/NIPT)	32	32	0.28
Genome-wide NIPs/NIPT	3	3	0.03
Panel testing	38	38	0.33
Polymerase Chain Reaction (PCR)	2	2	0.02
Pre-implantation Genetic Diagnosis (PGD)	1	1	0.01
Pharmacogenetic testing	1	1	0.01
Somatic testing	1	1	0.01
Whole Genome Sequencing/Whole Exome Sequencing (WGS/WES)	28	27	0.24
Meta-trends	24	17	0.15
Combination of events	6	6	0.05
Evolution of innovations	11	8	0.07
Multiple/continuous triggers	7	6	0.05

Other triggers	14	13	0.11
Guidelines (testing criteria, management)	1	1	0.01
Increased patient load	1	1	0.01
New job	4	4	0.04
New online resources	2	2	0.02
Supreme Court ruling on gene patents	6	6	0.05
IMPACT	**365**	**104**	**0.91**
Initial reactions/perceptions	134	64	0.56
Acknowledgement of impending shift	7	7	0.06
Apprehensive	16	15	0.13
Cautious	4	4	0.04
Challenged	7	7	0.06
Altered conception of the profession	3	2	0.02
Confused	2	2	0.02
Considering patients	15	12	0.11
Disheartened/disappointed	4	3	0.03
Excited	18	16	0.14
Frustrated	5	4	0.04
Gradual awareness	1	1	0.01
Need for support	3	3	0.03
Lack of knowledge/skill/experience	13	11	0.10
Motivated	4	4	0.04
Nostalgic	1	1	0.01
Perceived an opportunity	6	6	0.05
Noted others' reactions	3	3	0.03
Overwhelmed	10	10	0.09
Raised awareness/more critical	2	2	0.02
Uncertain	5	5	0.04
Validated	5	4	0.04
Magnitude	42	34	0.30
Sweeping statements	37	32	0.28
Collective response	5	3	0.03
Implications for practice	189	81	0.71
Adjustment (general)	22	21	0.18
Modifying systems/policies/procedures	12	12	0.11
Altered logic	3	3	0.03
Availability/access	5	4	0.04
Better testing/enhancement	3	3	0.03
Specific changes to practice	37	29	0.25

Informed consent	19	17	0.15
Something lost	2	2	0.02
Complexity	37	27	0.24
Difficult to keep up/stay current	2	2	0.02
More choices/options	18	16	0.14
More uncertain results	5	5	0.04
Financial considerations	15	11	0.10
Instigated learning	12	10	0.09
Longer sessions	5	5	0.04
More answers	3	3	0.03
New hope/promise	5	5	0.04
New responsibilities	6	6	0.05
Now/new common practice	7	7	0.06
Number of encounters	6	6	0.05
Increased patient volume	4	4	0.04
Fewer sessions with patient	2	2	0.02
Physicians' role	7	7	0.06
Rapidity of change	4	4	0.04
Replacement of previous options	4	4	0.04
Uncertainty	8	8	0.07
INSIGHTS	**49**	**37**	**0.32**
Impediments to changing practice	11	7	0.06
Lessons on learning	27	25	0.22
Intuitive process	2	2	0.02
Purposefulness of learning	5	5	0.04
Initiative needed	5	4	0.04
Knowledge is power	2	2	0.02
Safety in numbers	3	3	0.03
Dig deeper	3	3	0.03
Ownership of learning process	11	11	0.10
			0.00
LEARNING	**1064**	**114**	**1.00**
Graduate school foundation	4	4	0.04
Collaboration with others	695	105	0.92
Aim/focus/goal of collaboration	93	54	0.47
Pooling…	20	16	0.14
Experiences	9	9	0.08
Efforts	1	1	0.01
Ideas	2	2	0.02
Learning experiences	2	2	0.02

Practices	6	6	0.05
Professional opinion	73	47	0.41
Expertise	3	3	0.03
Approach (skill/how)	26	22	0.19
Information (knowledge/what)	32	25	0.22
Interpretation (attitude/why)	12	12	0.11
Context of collaboration	94	58	0.51
Immediate	10	8	0.07
Practice	10	8	0.07
Local setting	17	11	0.10
Case conference	4	4	0.04
Conference/meeting	5	5	0.04
Journal club	8	5	0.04
National scope	67	47	0.41
Conference/meeting	44	36	0.32
Listserv	12	9	0.08
SIG	11	10	0.09
Results of learning through collaboration	28	20	0.18
Application	6	5	0.04
Consistency of practice	2	2	0.02
Decision-making	4	4	0.04
Insights/new ideas	5	5	0.04
Stay current	3	2	0.02
Support received	3	3	0.03
Validation	5	5	0.04
People with whom to collaborate	276	99	0.87
Colleagues (general)	204	91	0.80
Friends	4	4	0.04
Classmates	6	6	0.05
Peers	3	3	0.03
Physicians	30	26	0.23
Non-GC, non-physician	8	8	0.07
Co-workers	36	33	0.29
Genetic counselors (GCs)	61	46	0.40
Same specialty	6	6	0.05
Similar circumstance	2	2	0.02
Unspecified	44	33	0.29
More experienced	11	11	0.10
Younger	1	1	0.01
Lab personnel	51	39	0.34
Lab genetic counselors (GCs)	17	15	0.13

Authors/experts	6	5	0.04
Patients	3	3	0.03
Students	3	2	0.02
Employer	1	1	0.01
Unspecified	8	7	0.06
Process by which collaboration is carried out	204	90	0.79
Observe	4	3	0.03
Listen	2	2	0.02
Teach	3	3	0.03
Feedback, received	3	3	0.03
Supervision	1	1	0.01
Networking	2	2	0.02
Unspecified	11	10	0.09
Share resources	4	3	0.03
Discuss/consult	153	84	0.74
Analyze/assess	9	9	0.08
Work together	12	9	0.08
Experimentation	54	33	0.29
Construct resources	18	15	0.13
Test tools/databases	2	2	0.02
Formalized information	270	87	0.76
Provided by...	52	34	0.30
Internal/institution	8	6	0.05
Colleagues	1	1	0.01
Professional societies	18	15	0.13
Testing laboratories	25	20	0.18
Reading	59	44	0.39
Guidelines/standards	14	12	0.11
Online resources	24	21	0.18
Lay literature	2	2	0.02
Consent forms	3	3	0.03
Books	3	3	0.03
Classes/coursework	6	5	0.04
Lecture/presentation/talk	46	30	0.26
Webinar	20	17	0.15
Articles/literature/papers	107	62	0.54
PubMed	5	5	0.04
Up-to-date/current/new	12	11	0.10
Frequency/depth	14	12	0.11
Multipurpose learning	15	8	0.07

Credentials (to result in)	2	1	0.01
Research (by conducting)	9	6	0.05
Teaching	3	3	0.03
Personal life (through connections)	1	1	0.01
Self-assessment	4	2	0.02
Unspecified	18	17	0.15
Time/wait and see	4	2	0.02
OUTCOME	**360**	**109**	**0.96**
Change (general)	66	46	0.40
No change/outcome…	18	16	0.14
Status quo	9	8	0.07
Just starting out	6	6	0.05
Perpetual change	48	35	0.31
Need for ongoing learning	14	14	0.12
In progress	16	14	0.12
New/additions to practice	18	15	0.13
New tools/skills	9	9	0.08
Different job	4	4	0.04
Addition/extension of previous approach	5	5	0.04
Practice implications	140	67	0.59
Time	8	6	0.05
Less	3	3	0.03
More	5	4	0.04
Counseling aspects	52	35	0.31
Post-test session	5	5	0.04
Pre-test session	8	7	0.06
Changed counseling approach	39	34	0.30
Expanded	2	2	0.02
Generalized info	4	4	0.04
Made more accessible	2	2	0.02
Specified info/detail	11	9	0.08
Pace of change to practice	9	8	0.07
Rapid	4	4	0.04
Slow	5	4	0.04
Qualitative difference	11	9	0.08
Complicated matters	2	2	0.02
Testing aspects	55	35	0.31
Autonomy in decision-making	1	1	0.01
Altered testing strategy	54	34	0.30
Restricted access	5	3	0.03

Lab choices	6	6	0.05
Recipients/population to be tested	6	6	0.05
Incorporated testing	26	21	0.18
Routinized	9	9	0.08
Variant of Uncertain Significance (VOUS/VUS)	5	5	0.04
New perspectives	134	75	0.66
General	22	18	0.16
Lingering uncertainty	5	5	0.04
Greater knowledge overall	6	6	0.05
Enhanced diagnostics	9	9	0.08
Related to practice	61	47	0.41
Consenting philosophies	7	7	0.06
Regarding patients	14	14	0.12
Into others	5	5	0.04
Regarding oneself	46	31	0.27
Accept limitations	4	3	0.03
Confidence	10	8	0.07
Flexibility	6	6	0.05
Validation	2	2	0.02
Frustration	2	2	0.02
Acceptance	5	5	0.04
Pay it forward	2	2	0.02

Appendix D

Excerpt from Coded Critical Incident Questionnaire

..WGS/WES
..Financial considerations
..Excited
..More answers

Q15.

At what point in your career has your approach to your genetic counseling been most impacted by a scientific innovation?

Describe the situation. What was the innovation? What were you thinking, feeling, or doing at the time? In what ways was your practice affected?

Although I am still quite new to the field, in starting my first job I immediately noticed that whole exome sequencing was used much more frequently than in my graduate school training. Rather than a brand new innovation, the scale had tipped just enough that WES was financially possible in most situations when we would want to order it, as opposed to only in rare cases where funding was available. I felt excited by this availability as it was something we discussed in grad school as the future of clinical genetics, and it actually happened a little sooner than I would have guessed. My practice was affected positively because it has definitely shortened the diagnostic odyssey for many of my patients.

..Constructing resources
..Graduate school foun
..Unspecified
..Discuss/consult
..Consent forms
..Lab information
..Guidelines/standards

Q16.

How did you learn to adjust your practice?

What learning strategies did you pursue? What resources did you use? With whom did you consult?

I feel back on my grad school practices of overly preparing a script to use while discussing WES and consenting patients. I wouldn't do this for most cases but because I knew I would be using WES so often I wanted to have a strong grasp on it and make sure I was accurately portraying it to patients. I talked with my colleagues and also used the consent form from the lab as a reference. I read a bit into the practice guidelines about incidental findings and disclosure of non-paternity.

..Observed
..Co-workers
..Practice
..Information (knowledge/what

Q18.

What action (if any) did you find most helpful?

What was the most important step you took? What action did anyone else take?

Because my coworkers had been doing it before I started, I shadowed them at the beginning of my job and paid especially close attention to the WES cases and what was discussed.

..Opportunity
..More
..Made more accessible
..Pre-test
..Confidence
..Perpetual change
..About practice
..Need for ongoing learing

Q19.

What were the outcomes?

How did your practice change? What was the most important information you learned from the process?

Because this change occurred while I am still very new and learning constantly, incorporating WES as a frequent tool in my practice has been a great chance to work on counseling skills. We have a much longer discussion about WES with patients than we routinely have about any other genetic test, so it is a good challenge to make such a huge genetic test feel understandable to all different types of patients. I feel like I am a better GC because of this opportunity, and I have a better appreciation for how genetic testing is not static but something that we need to constantly keep up with and evaluate.

Q20.

The following is an optional component to this questionnaire. It is an assessment of how someone might perceive and respond to uncertain or ambiguous situations. If you are interested in participating in this component of the study, please respond to each item with a score on a scale of 1 to 7, with 1 being "strongly disagree" to 7 as "strongly agree".

Image 1. Excerpt of coded critical incident questionnaire.

Appendix E

Chi Square Goodness-of-fit Statistics for Learning Strategies Codes

Table 9

Learning Strategies by Specialty

	PRENATAL	CANCER	PEDS	MULTIPLE CLINICAL	LAB	RESEARCH	OTHER	TOTAL	CHI SQUARE
POOLING	2	8	0	1	1	1	3	16	
	3.12	4.25	1.42	1.42	1.42	0.85	3.54		0.48
PROFESSIONAL OPINION	6	13	4	5	3	4	11	46	
	8.96	12.21	4.07	4.07	4.07	2.44	10.18		0.86
NATIONAL CONFERENCE	5	6	4	3	4	3	11	36	
	7.01	9.56	3.19	3.19	3.19	1.91	7.96		0.66
GC COLLEAGUES	7	14	2	4	3	3	9	42	
	8.18	11.15	3.72	3.72	3.72	2.23	9.29		0.91
DISCUSS/CONSULT	19	20	5	8	6	4	21	83	
	16.16	22.04	7.35	7.35	7.35	4.41	18.36		0.90
EXPERIMENTATION	3	10	4	4	1	1	9	32	
	6.23	8.50	2.83	2.83	2.83	1.70	7.08		0.56
READING	8	12	6	4	2	2	9	43	
	8.37	11.42	3.81	3.81	3.81	2.28	9.51		0.90
LECTURE/PRESENTATION/TALK	7	6	0	5	3	3	6	30	
	5.84	7.96	2.65	2.65	2.65	1.59	6.64		0.34
ARTICLES/LITERATURE/PAPERS	17	9	4	4	8	6	14	62	
	12.07	16.46	5.49	5.49	5.49	3.29	13.72		0.14
N (RESPONDENTS)	22	30	10	10	10	6	25	113	
N/113	0.19	0.27	0.09	0.09	0.09	0.05	0.22		

Table 10

Learning Strategies by Years of Experience in Genetic Counseling

	0-4 YEARS	5-9 YEARS	10-14 YEARS	15+ YEARS	TOTAL	CHI SQUARE
POOLING	9	4	2	1	16	
	6.46	3.51	1.96	4.07		0.34
PROFESSIONAL OPINION	24	10	5	8	47	
	18.96	10.31	5.77	11.96		0.43
NATIONAL CONFERENCE	11	6	7	12	36	
	14.53	7.89	4.42	9.16		0.30
GC COLLEAGUES	22	10	3	8	43	
	17.35	9.43	5.28	10.94		0.38
DISCUSS/CONSULT	38	21	9	16	84	
	33.89	18.42	10.32	21.37		0.50
EXPERIMENTATION	13	7	4	9	33	
	13.32	7.24	4.05	8.39		1.00
READING	15	12	5	12	44	
	17.75	9.65	5.40	11.19		0.78
LECTURE/PRESENTATION/TALK	13	5	4	8	30	
	12.11	6.58	3.68	7.63		0.92
ARTICLES/LITERATURE/PAPERS	19	18	9	16	62	
	25.02	13.60	7.61	15.77		0.37
N (RESPONDENTS)	**46**	**25**	**14**	**29**	**114**	
N/114	**0.40**	**0.22**	**0.12**	**0.25**		

Table 11

Learning Strategies by Ambiguity Tolerance Score

	< 56	56-61	62-67	> 67	TOTAL	CHI SQUARE
POOLING	7	4	1	4	16	
	4.23	3.77	3.17	4.83		0.33
PROFESSIONAL OPINION	13	10	8	13	44	
	11.62	10.38	8.72	13.28		0.97
NATIONAL CONFERENCE	3	11	7	11	32	
	8.45	7.55	6.34	9.66		0.15
GC COLLEAGUES	12	8	5	14	39	
	10.30	9.20	7.73	11.77		0.61
DISCUSS/CONSULT	25	20	12	22	79	
	20.87	18.63	15.6 5	23.85		0.59
EXPERIMENTATION	9	8	5	10	32	
	8.45	7.55	6.34	9.66		0.95
READING	8	9	11	13	41	
	10.83	9.67	8.12	12.38		0.61
LECTURE/PRESENTATION/TALK	5	8	9	6	28	
	7.40	6.60	5.55	8.45		0.27
ARTICLES/LITERATURE/PAPERS	12	16	12	16	56	
	14.79	13.21	11.0 9	16.91		0.74
N (RESPONDENTS)	**28**	**25**	**21**	**32**	**106**	
N/106	**0.26**	**0.24**	**0.20**	**0.30**		

Appendix F

Ambiguity Tolerance Statistics

Table 12

Descriptive Statistics of Total Sample of Ambiguity Tolerance (AT) Assessments

		ATSCORE	AGE	YEARSGC
N		135	135	135
Mean		60.55	36.00	9.36
Median		61.00	33.00	6.50
Mode		61	26	2
Std. Deviation		10.952	9.856	8.680
Range		50	39	37
Minimum		35	23	0
Maximum		85	62	37
Percentiles	25	54	28	2
	50	61	33	6.5
	75	68	42	14

Table 13

Descriptive Statistics of AT Score by Specialty Categories

SPECIALTY	N	Mean	Median	Std. Dev.	Minimum	Maximum
Prenatal	27	59.26	59.00	11.065	37	80
Cancer	32	58.66	61.00	9.390	42	81
Pediatric/general genetics	13	62.38	66.00	13.866	41	84
Multiple clinical	15	63.33	65.00	12.915	39	85
Laboratory	2	65.00	65.00	5.657	61	69
Research	5	59.60	61.00	9.209	48	71
Other	40	61.00	60.00	10.997	35	81
None	1	68.00	68.00		68	68
Total	135	60.55	61.00	10.952	35	85

Table 14

Linear Regression: AT Score by Specialty as Categorical Variable

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.152[a]	.023	-.023	11.099	.023	.503	6	127	.805

a. Predictors: (Constant), Specialty6, Specialty5, Specialty4, Specialty3, Specialty1, Specialty2

Table 15

Coefficients Table for Regression of AT Score by Specialty as Categorical Variable

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	371.478	6	61.913	.503	.805[b]
	Residual	15646.014	127	123.197		
	Total	16017.493	133			

a. Dependent Variable: ATSCORE

b. Predictors: (Constant), Specialty6, Specialty5, Specialty4, Specialty3, Specialty1, Specialty2

Table 16

One-way ANOVA: AT Scores by Clinical Versus Non-Clinical Specialties (Categorical Variable)

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	20.238	1	20.238	.167	.683
Within Groups	15997.255	132	121.191		
Total	16017.493	133			

Table 17

Descriptive Statistics of AT Score by Years of Experience in Genetic Counseling

YEARS GC	N	Mean	Median	Std. Deviation	Minimum	Maximum
0-4	54	60.33	61.00	11.016	35	85
5-9	30	60.37	60.00	8.604	43	80
10-14	18	60.78	60.00	9.072	44	77
15+	33	60.94	65.00	13.791	36	84
Total	135	60.55	61.00	10.952	35	85

Table 18

Linear Regression: AT Score by Years of Experience as a Continuous Variable

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	96.812	1	96.812	.806	.371[b]
	Residual	15976.625	133	120.125		
	Total	16073.437	134			

a. Dependent Variable: ATSCORE

b. Predictors: (Constant), YEARSGC

Table 19

Coefficients Table for Regression of AT Score by Years of Experience as a Continuous Variable

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	59.632	1.390		42.912	.000
	YEARSGC	.098	.109	.078	.898	.371

a. Dependent Variable: ATSCORE

Table 20

Linear Regression: AT Score by Age as a Continuous Variable

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	180.083	1	108.083	1.507	.222[b]
	Residual	15893.354	133	119.499		
	Total	16073.437	134			

a. Dependent Variable: ATSCORE

b. Predictors: (Constant), AGE

Table 21

Coefficients Table for Regression of AT Score by Age as a Continuous Variable

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	56.314	3.575		15.750	.000
	AGE	.118	.096	.106	1.228	.222

a. Dependent Variable: ATSCORE

Appendix G

Interview Protocol

- Thanks, introduction
    - As a reminder, this interview is being audio-recorded.
- Frame with gratitude for completing questionnaire and your responses have been very helpful. Discuss how it's an interesting time to be working in this field.
- In this interview, I will ask you about your thoughts on professional learning and development. These questions ask you to consider both your general approach and specific examples.
- Questions:
    1. I note from the online questionnaire you submitted that you have worked in [specialty] for [years of experience]. Is that right? And [innovation] came up recently – what was that like for you?
        a. What/how were you thinking and feeling about being a genetic counselor at that time?
    2. Generally speaking, when and in what ways are you most aware at a conscious level that you are learning as a part of your job?
        a. With what frequency does this occur to you? Daily/monthly/annually?
        b. When/How/In what ways/At what times do you recognize that adjusting practice/acquiring more knowledge or skill is needed?
    3. Tell me about the last two or three things that you've done to update/adjust your practice.
        a. What prompted the change?
        b. How have you most recently changed what you do?
        c. What's now different about your approach?
        d. How did you know when you've learned what it is you were aiming to learn?
    4. Let's move on to strategies you use for adjusting/updating practice. Could you describe for me how you go about learning related to your work (build on response to question 3 when possible)?
        a. How typical is this approach for you?
        b. If [strategy/resource] wasn't available to you, what would you do?
        c. [If attend conference or read literature: How do you go about applying what you learned to your work? To what extent was applying this learning easy or challenging? What examples come to mind?]
    5. Many genetic counselors rely on colleagues to help them in their learning and professional practice. To what extent would you say this is true for you?
        a. In what ways do you rely on colleagues?
        b. When turning to colleagues, what are you hoping to learn from them?
        c. How do they help you learn?

    d. What might prompt you to turn to one colleague versus another? [Consider different settings, specialties: in the office versus at a conference, from commercial lab versus clinical contacts]
6. In terms of professional learning overall, what are the challenges you encounter?
    a. How do you address these challenges?
7. What or who best supports you in your learning? How/why?
8. What advice would you give to genetic counselors about how to stay current or change their practice, about how to continue learning throughout their career?
    a. If you were to write a guideline for genetic counselors about professional learning and development, what would it say?
9. What (if any) guidance or messaging about professional learning do you receive from colleagues or professional societies?
10. Is there anything you think I should have asked with respect to professional learning for genetic counselors?

- Thanks, and may I contact you for further clarification as needed?
    - Would you be willing to receive a personalized link to a follow-up survey such that your otherwise anonymized responses could be correlated?

Appendix H

Demographic Information for Interviewees

Table 22

Summary of Interviewee Demographics

	Frequency	Percent	Range
Gender			
Female	20	95.2	
Male	1	4.8	
Prefer not to answer	0	0	
Age	Average = 36.4		24-62
Years working as a genetic counselor	Average = 9.4		0.5-35
Primary specialty area			
Prenatal	2	9.5	
Cancer	5	23.8	
Pediatric/general genetics	4	19.0	
Laboratory	3	14.3	
Research	3	14.3	
Other	4	19.0	
Years in primary specialty	Average = 8.0		0.33-35
Highest degree earned			
Masters in genetic counseling or related degree	19	90.5	
Some post-graduate work	1	4.8	
Doctoral degree	1	4.8	
Certification status			
Certified	20	95.2	
Board-eligible	1	4.8	
Not certified	0		

Table 23

Pseudonyms for Interviewees and Associated Demographics

	Gender	Age	Years of experience	Years in specialty	State	Context	Education level	AT score
PRENATAL								
Lucy	Female	28	1.5	1.5	TX	University medical center	Masters in genetic counseling or related degree	-
Charlotte	Female	39	14	11	OR	University medical center	Masters in genetic counseling or related degree	59
CANCER								
Caroline	Female	29	4	4	NY	Private hospital	Masters in genetic counseling or related degree	57
Lydia	Female	26	1	1	VA	Public hospital	Masters in genetic counseling or related degree	61
Louisa	Female	33	7	7	VA	University medical center	Masters in genetic counseling or related degree	61
Henrietta	Female	37	11	10	NJ	Diagnostic lab	Some post-graduate work	69
Mary	Female	62	16	16	GA	Non-profit organization	Masters in genetic counseling or related degree	67
PEDIATRICS								
Kitty	Female	24	0.5	0.5	MO	University medical center	Masters in genetic counseling or related degree	83
Susan	Female	24	0.5	0.5	IA	University medical center	Masters in genetic counseling or related degree	48
Jane	Female	50	5	5	NY	University medical center	Masters in genetic counseling or related degree	68
LABORATORY								
Mariah	Female	33	9	5	NY	Diagnostic lab	Masters in genetic counseling or related degree	-
Betsy	Female	38	14	4.5	OH	Private hospital	Masters in genetic counseling or related degree	67

Elinor	Female	52	25	8	TX	Diagnostic lab	Masters in genetic counseling or related degree	65
RESEARCH								
Margarette	Female	31	7	4	MD	University medical center	Masters in genetic counseling or related degree	48
Marianne	Female	31	7	7	NC	University medical center	Masters in genetic counseling or related degree	65
Lizzie	Female	36	8	8	NY	University medical center	Masters in genetic counseling or related degree	53
OTHER								
Georgiana	Female	25	1.5	1.5	KY	University medical center	Masters in genetic counseling or related degree	63
Darcy	Male	35	8	8	NY	Industry	Masters in genetic counseling or related degree	59
Julia	Female	35	9.5	9.5	IN	Private hospital	Masters in genetic counseling or related degree	66
Fanny	Female	38	12	12	IA	University medical center	Doctoral degree in Molecular Genetics	77
Anne	Female	59	35	25	WI	University medical center	Masters in genetic counseling or related degree	78

Image 2. Geographic distribution of interviewees.

Appendix I

Coding Scheme for Interviews

Table 24

Interview Coding Scheme

CODING SYSTEM	# coded segments	# total participants	% total participants
	1043	21	
OPPORTUNITIES FOR LEARNING	183	21	1.00
Directed learning	4	3	0.14
Structured activities, dedicated time	44	16	0.76
Grand rounds/seminars	4	3	0.14
Group work	7	5	0.24
National conference	14	10	0.48
Frequency	29	20	0.95
Constantly	5	4	0.19
Daily	12	11	0.52
Monthly	2	2	0.10
Weekly	10	10	0.48
Learning by teaching	10	5	0.24
Precipitants	85	21	1.00
New info	8	6	0.29
New job	2	2	0.10
Personal interest	5	4	0.19
Practice	39	18	0.86
Recognized gap in knowledge	16	12	0.57
Self-awareness	3	1	0.05
Task preparation	12	7	0.33
Online resources	11	9	0.43
LEARNING PROCESS	450	21	1.00
Alternatives	29	13	0.62
Books	4	4	0.19
Conferences, courses	5	3	0.14
Does not compute	5	5	0.24
Reflection	4	4	0.19

Reworking trusted approaches	3	3	0.14
Someone else	8	6	0.29
Challenges	92	21	1.00
Access	7	7	0.33
Rate of learning	5	3	0.14
Credentials	7	2	0.10
Expense	10	7	0.33
Faulty foundation	6	6	0.29
Initiative	3	2	0.10
Lack of specific resources	15	9	0.43
Outdated	2	2	0.10
Parity	2	1	0.05
Shared language	2	1	0.05
Time	38	13	0.62
Competing commitments	17	10	0.48
Prioritizing	8	7	0.33
Colleagues	217	21	1.00
Choice of learning partners	130	21	1.00
Coincidence	1	1	0.05
Alternative perspective	12	9	0.43
Analogy	5	4	0.19
Buy-in	3	1	0.05
Expertise	75	18	0.86
Degree	2	1	0.05
Experience	17	14	0.67
Referral	2	2	0.10
Posting/publishing	3	2	0.10
Role/title	22	12	0.57
Personal connection	11	9	0.43
Respect	1	1	0.05
Personality	6	5	0.24
Judgment	2	2	0.10
Proximity/access	8	7	0.33
Topic/question dependent	8	7	0.33
Collaborative problem-solving	18	11	0.52
Discussion and dialogue	41	18	0.86
Patients	3	3	0.14
Pooling experiences	14	13	0.62
Validation/feedback	9	8	0.38
Critical feedback	1	1	0.05
Conferences	4	4	0.19

Interactivity	11	8	0.38
Mentoring	7	3	0.14
Reading, researching	40	17	0.81
Familiar resources	22	14	0.67
Reflection/critical thinking	35	14	0.67
Application/connections	16	8	0.38
Self-direction	5	4	0.19
Training	2	2	0.10
Writing	5	2	0.10
EVIDENCE OF LEARNING	54	20	0.95
Ability to explain	22	12	0.57
Answer questions	3	3	0.14
Follow-through	1	1	0.05
Patient achieves understanding	2	2	0.10
Feedback	6	4	0.19
Just do it	5	5	0.24
New perspective/insight	11	8	0.38
Feel prepared	3	3	0.14
Practice makes perfect	4	3	0.14
Saturation	6	5	0.24
ADVICE	65	21	1.00
Acknowledge limitations	2	2	0.10
Cultivate a formal network	10	9	0.43
Find your passion	3	2	0.10
Cast a wide net	33	13	0.62
Escape the bubble/interdisciplinarity	14	9	0.43
Reflective practice/big picture	8	6	0.29
New job	1	1	0.05
Peruse the literature landscape	2	2	0.10
Supportive environment	3	2	0.10
Take advantage	11	7	0.33
MESSAGING	111	19	0.90
CEUs	8	7	0.33
Collegial	2	2	0.10
Exciting	2	1	0.05
Important/valuable	8	7	0.33
Lacking	3	3	0.14
Not a priority	2	2	0.10

Primacy of patient care	2	2	0.10
Requirement/procedural	8	6	0.29
Source	50	19	0.90
Employer	11	7	0.33
Colleagues	5	3	0.14
Professional societies	20	14	0.67
Profession in general	7	6	0.29
Training programs	7	6	0.29
Specialization implications	5	3	0.14
Supportive, provide resources	21	14	0.67
BROAD THEMES	121	20	0.95
Awareness of not knowing	5	4	0.19
Constant learning	22	13	0.62
Desire vs. require	13	8	0.38
Evolving profession	17	10	0.48
Perpetually	8	7	0.33
Quickly	9	5	0.24
Formal/informal	14	7	0.33
Interdisciplinarity	16	11	0.52
Learning to learn	6	4	0.19
Networking	14	9	0.43
Protected time	14	6	0.29
Timeliness	6	3	0.14

Appendix J

Analysis of Influence of Interviewees' Specialties

Table 25

Interview Coding by Specialty Categories

Specialty	Pren.		Cancer					Peds			Lab.			Research			Other					
Interviewees	Lucy	Charlotte	Caroline	Lydia	Louisa	Henrietta	Mary	Kitty	Susan	Jane	Mariah	Betsy	Elinor	Margarette	Marianne	Lizzie	Georgiana	Darcy	Julia	Fanny	Anne	**Total**
ADVICE																						
Acknowledge limitations			✓		✓																	2
Cultivate a formal network				✓	✓			✓		✓		✓		✓			✓	✓	✓			9
Find your passion						✓														✓		2
Cast a wide net	✓					✓	✓		✓				✓		✓					✓	✓	8
Escape the bubble/interdisciplinarity	✓	✓				✓	✓				✓	✓	✓			✓				✓		9
Reflective practice/big picture	✓					✓				✓			✓			✓					✓	6
New job											✓											1
Peruse the literature landscape							✓		✓													2
Supportive environment			✓														✓					2
Take advantage	✓	✓		✓					✓							✓		✓		✓		7

BROAD THEMES																						
Awareness of not knowing		✓	✓						✓								✓					4
Constant learning	✓	✓	✓	✓		✓	✓	✓	✓	✓				✓					✓	✓	✓	13
Desire vs. require			✓		✓	✓			✓				✓		✓	✓					✓	8
Evolving profession																						0
Perpetually	✓			✓		✓		✓		✓						✓			✓			7
Quickly	✓		✓					✓				✓								✓		5
Formal/informal		✓				✓			✓	✓			✓	✓	✓							7
Interdisciplinarity		✓					✓			✓	✓	✓	✓	✓	✓	✓	✓			✓		11
Learning to learn			✓			✓						✓				✓						4
Networking	✓	✓			✓	✓	✓	✓		✓			✓							✓		9
Protected time	✓		✓						✓													3
Timeliness					✓			✓				✓										3
EVIDENCE OF LEARNING																						
Ability to explain		✓		✓	✓	✓	✓	✓		✓					✓	✓		✓	✓			11
Answer questions		✓						✓							✓							3
Follow-through																		✓				1
Patient achieves understanding	✓			✓																		2
Feedback								✓			✓		✓							✓		4
Just do it	✓						✓						✓	✓	✓							5
New perspective/insight									✓		✓								✓	✓	✓	5
Feel prepared								✓		✓						✓						3
Practice makes perfect				✓								✓								✓		3
Saturation	✓					✓				✓				✓			✓					5
LEARNING PROCESS																						
Alternatives																						0
Books	✓		✓									✓			✓							4

Conferences, courses						✓													✓	✓		3
Does not compute	✓													✓	✓	✓	✓					5
Reflection			✓							✓			✓					✓				4
Reworking trusted approaches														✓	✓				✓			3
Someone else												✓			✓	✓	✓	✓		✓		6
Challenges																					✓	1
Access					✓	✓				✓				✓				✓	✓		✓	7
Rate of learning	✓											✓								✓		3
Credentials												✓	✓									2
Expense	✓	✓					✓			✓				✓					✓		✓	7
Faulty foundation	✓		✓							✓		✓	✓		✓							6
Initiative		✓																✓				2
Lack of specific resources					✓			✓			✓		✓		✓	✓					✓	7
Outdated		✓											✓									2
Parity		✓																				1
Shared language																	✓					1
Time	✓			✓					✓	✓				✓	✓					✓	✓	8
Competing commitments	✓		✓	✓				✓	✓	✓			✓		✓			✓		✓		10
Prioritizing									✓	✓			✓	✓			✓			✓	✓	7
Colleagues			✓						✓	✓		✓	✓									5
Choice of learning partners											✓											1
Coincidence											✓											1
Alternative perspective	✓					✓		✓				✓	✓		✓	✓		✓			✓	9
Analogy							✓									✓			✓		✓	4
Buy-in																				✓		1
Expertise			✓	✓	✓	✓		✓	✓	✓		✓	✓	✓	✓	✓		✓		✓		14
Degree											✓											1

Experience		✓	✓	✓		✓		✓	✓	✓		✓	✓	✓	✓	✓	✓	✓				14
Referral						✓							✓									2
Posting/publishing						✓							✓									2
Role/title					✓			✓	✓		✓	✓	✓	✓	✓	✓	✓			✓	✓	12
Personal connection	✓				✓		✓	✓									✓	✓	✓	✓	✓	9
Respect																				✓		1
Personality	✓	✓	✓			✓																4
Judgment			✓											✓								2
Proximity/access	✓				✓	✓						✓		✓			✓				✓	7
Topic/question dependent			✓	✓	✓	✓		✓				✓		✓								7
Collaborative problem-solving	✓	✓	✓	✓						✓		✓	✓	✓		✓				✓	✓	11
Discussion and dialogue	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓			✓	✓	✓	✓	✓	✓	✓	✓	18
Patients	✓		✓								✓											3
Pooling experiences	✓			✓	✓	✓		✓	✓	✓		✓	✓		✓		✓		✓	✓		13
Validation/feedback			✓	✓				✓			✓					✓	✓		✓			7
Critical feedback																				✓		1
Conferences			✓	✓			✓							✓								4
Interactivity		✓					✓	✓				✓		✓	✓	✓			✓			8
Mentoring											✓						✓			✓		3
Reading, researching	✓	✓	✓			✓	✓	✓		✓				✓	✓	✓	✓	✓		✓		13
Familiar resources	✓	✓	✓		✓		✓			✓		✓	✓	✓	✓	✓	✓	✓	✓			14
Reflection/critical thinking	✓	✓	✓		✓	✓				✓	✓	✓				✓		✓			✓	11
Application/connections	✓			✓	✓	✓			✓							✓				✓	✓	8
Self-direction	✓					✓										✓		✓				4
Training							✓											✓				2
Writing							✓			✓												2

MESSAGING																						
CEUs				✓	✓								✓	✓	✓			✓			✓	7
Collegial	✓		✓																			2
Exciting								✓														1
Important/valuable	✓		✓					✓		✓			✓		✓					✓		7
Lacking						✓					✓							✓				3
Not a priority		✓									✓											2
Primacy of patient care																	✓	✓				2
Requirement/procedural					✓	✓			✓				✓							✓	✓	6
Source																						0
Employer	✓				✓	✓			✓						✓			✓		✓		7
Colleagues	✓							✓											✓			3
NSGC		✓	✓	✓		✓				✓	✓	✓	✓	✓	✓			✓	✓	✓	✓	14
Profession in general								✓	✓		✓	✓					✓	✓				6
Training programs	✓		✓					✓	✓		✓						✓					6
Specialization implications											✓		✓						✓			3
Supportive, provide resources	✓		✓	✓	✓	✓			✓			✓		✓	✓		✓	✓	✓	✓	✓	14
OPPORTUNITIES FOR LEARNING																						
Directed learning						✓					✓							✓				3
Structured activities, dedicated time	✓	✓		✓			✓		✓	✓								✓			✓	8
Grand rounds/seminars		✓							✓											✓		3
Group work		✓		✓	✓								✓			✓						5
National conference		✓		✓	✓					✓	✓	✓	✓	✓	✓						✓	10
Frequency																						0
Constantly						✓					✓				✓				✓			4

Daily		✓	✓			✓	✓	✓		✓	✓			✓	✓					✓	✓	11
Monthly				✓				✓														2
Weekly	✓	✓		✓					✓			✓	✓			✓	✓	✓			✓	10
Learning by teaching		✓								✓							✓	✓			✓	5
Precipitants																						0
New info				✓	✓						✓		✓	✓						✓		6
New job						✓														✓		2
Personal interest		✓				✓			✓						✓							4
Practice	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓		✓	✓		18
Recognized gap in knowledge	✓	✓	✓					✓		✓		✓	✓	✓	✓		✓	✓			✓	12
Self-awareness						✓																1
Task preparation		✓						✓		✓			✓					✓	✓	✓		7
Online resources		✓	✓	✓	✓		✓		✓		✓	✓			✓							9
Research ideas	✓								✓						✓		✓	✓	✓			6
Researcher rephrase	✓	✓	✓		✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	19
SUM	45	36	36	28	28	41	22	34	32	37	29	33	38	33	38	30	29	34	25	41	31	701
N (Documents)	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	21

Table 26

Proportion of Interviewees in Each Specialty Category with Statements Relevant to Code

	Pren.	Cancer	Peds	Lab	Res.	Other	Total
Advice	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Acknowledge limitations	0.00	0.40	0.00	0.00	0.00	0.00	0.10
Cultivate a formal network	0.00	0.40	**0.67**	0.33	0.33	**0.60**	0.43
Find your passion	0.00	0.20	0.00	0.00	0.00	0.20	0.10
Cast a wide net	0.50	0.40	0.33	0.33	0.33	0.40	0.38
Escape the bubble/interdisciplinarity	**1.00**	0.40	0.00	**1.00**	0.33	0.20	0.43
Reflective practice/big picture	0.50	0.20	0.33	0.33	0.33	0.20	0.29
New job	0.00	0.00	0.00	0.33	0.00	0.00	0.05
Peruse the literature landscape	0.00	0.20	0.33	0.00	0.00	0.00	0.10
Supportive environment	0.00	0.20	0.00	0.00	0.00	0.20	0.10
Take advantage	**1.00**	0.20	0.33	0.00	0.33	0.40	0.33
Broad themes	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Awareness of not knowing	0.50	0.20	0.33	0.00	0.00	0.20	0.19
Constant learning	**1.00**	**0.80**	**1.00**	0.00	0.33	**0.60**	**0.62**
Desire vs. require	0.00	**0.60**	0.33	0.33	**0.67**	0.20	0.38
Evolving profession	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Perpetually	0.50	0.40	**0.67**	0.00	0.33	0.20	0.33
Quickly	0.50	0.20	0.33	0.33	0.00	0.20	0.24
Formal/informal	0.50	0.20	**0.67**	0.33	**0.67**	0.00	0.33
Interdisciplinarity	0.50	0.20	0.33	**1.00**	**1.00**	0.40	**0.52**
Learning to learn	0.00	0.40	0.00	0.33	0.33	0.00	0.19
Networking	**1.00**	**0.60**	**0.67**	0.33	0.00	0.20	0.43
Protected time	0.50	0.20	0.33	0.00	0.00	0.00	0.14
Timeliness	0.00	0.20	0.33	0.33	0.00	0.00	0.14
Evidence of learning	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ability to explain	0.50	**0.80**	**0.67**	0.00	**0.67**	0.40	**0.52**
Answer questions	0.50	0.00	0.33	0.00	0.33	0.00	0.14
Follow-through	0.00	0.00	0.00	0.00	0.00	0.20	0.05
Patient achieves understanding	0.50	0.20	0.00	0.00	0.00	0.00	0.10
Feedback	0.00	0.00	0.33	**0.67**	0.00	0.20	0.19
Just do it	0.50	0.20	0.00	0.33	**0.67**	0.00	0.24
New perspective/insight	0.00	0.00	0.33	0.33	0.00	**0.60**	0.24
Feel prepared	0.00	0.00	**0.67**	0.00	0.33	0.00	0.14

Practice makes perfect	0.00	0.20	0.00	0.33	0.00	0.20	0.14
Saturation	0.50	0.20	0.33	0.00	0.33	0.20	0.24
Learning process	0.50	0.20	0.00	0.00	0.00	0.00	0.10
Alternatives	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Books	0.50	0.20	0.00	0.33	0.33	0.00	0.19
Conferences, courses	0.00	0.20	0.00	0.00	0.00	0.40	0.14
Does not compute	0.50	0.00	0.00	0.00	**1.00**	0.20	0.24
Reflection	0.00	0.20	0.33	0.33	0.00	0.20	0.19
Reworking trusted approaches	0.00	0.00	0.00	0.00	**0.67**	0.20	0.14
Someone else	0.00	0.00	0.00	0.33	**0.67**	**0.60**	0.29
Challenges	0.00	0.00	0.00	0.00	0.00	0.20	0.05
Access	0.00	0.40	0.33	0.00	0.33	**0.60**	0.33
Rate of learning	0.50	0.00	0.00	0.33	0.00	0.20	0.14
Credentials	0.00	0.00	0.00	**0.67**	0.00	0.00	0.10
Expense	**1.00**	0.20	0.33	0.00	0.33	0.40	0.33
Faulty foundation	0.50	0.20	0.33	**0.67**	0.33	0.00	0.29
Initiative	0.50	0.00	0.00	0.00	0.00	0.20	0.10
Lack of specific resources	0.00	0.20	0.33	**0.67**	**0.67**	0.20	0.33
Outdated	0.50	0.00	0.00	0.33	0.00	0.00	0.10
Parity	0.50	0.00	0.00	0.00	0.00	0.00	0.05
Shared language	0.00	0.00	0.00	0.00	0.00	0.20	0.05
Time	0.50	0.20	**0.67**	0.00	**0.67**	0.40	0.38
Competing commitments	0.50	0.40	**1.00**	0.33	0.33	0.40	0.48
Prioritizing	0.00	0.00	**0.67**	0.33	0.33	**0.60**	0.33
Colleagues	0.00	0.20	**0.67**	**0.67**	0.00	0.00	0.24
Choice of learning partners	0.00	0.00	0.00	0.33	0.00	0.00	0.05
Coincidence	0.00	0.00	0.00	0.33	0.00	0.00	0.05
Alternative perspective	0.50	0.20	0.33	**0.67**	**0.67**	0.40	0.43
Analogy	0.00	0.20	0.00	0.00	0.33	0.40	0.19
Buy-in	0.00	0.00	0.00	0.00	0.00	0.20	0.05
Expertise	0.00	**0.80**	**1.00**	**0.67**	**1.00**	0.40	**0.67**
Degree	0.00	0.00	0.00	0.33	0.00	0.00	0.05
Experience	0.50	**0.60**	**1.00**	**0.67**	**1.00**	0.40	**0.67**
Referral	0.00	0.20	0.00	0.33	0.00	0.00	0.10
Posting/publishing	0.00	0.20	0.00	0.33	0.00	0.00	0.10
Role/title	0.00	0.20	**0.67**	**1.00**	**1.00**	**0.60**	**0.57**
Personal connection	0.50	0.40	0.33	0.00	0.00	**1.00**	0.43
Respect	0.00	0.00	0.00	0.00	0.00	0.20	0.05
Personality	**1.00**	0.40	0.00	0.00	0.00	0.00	0.19

Judgment	0.00	0.20	0.00	0.00	0.33	0.00	0.10
Proximity/access	0.50	0.40	0.00	0.33	0.33	0.40	0.33
Topic/question dependent	0.00	**0.80**	0.33	0.33	0.33	0.00	0.33
Collaborative problem-solving	**1.00**	0.40	0.33	**0.67**	**0.67**	0.40	**0.52**
Discussion and dialogue	**1.00**	**0.80**	**1.00**	0.33	**1.00**	**1.00**	**0.86**
Patients	0.50	0.20	0.00	0.33	0.00	0.00	0.14
Pooling experiences	0.50	**0.60**	**1.00**	**0.67**	0.33	**0.60**	**0.62**
Validation/feedback	0.00	0.40	0.33	0.33	0.33	0.40	0.33
Critical feedback	0.00	0.00	0.00	0.00	0.00	0.20	0.05
Conferences	0.00	**0.60**	0.00	0.00	0.33	0.00	0.19
Interactivity	0.50	0.20	0.33	0.33	**1.00**	0.20	0.38
Mentoring	0.00	0.00	0.00	0.33	0.00	0.40	0.14
Reading, researching	**1.00**	**0.60**	**0.67**	0.00	**1.00**	**0.60**	**0.62**
Familiar resources	**1.00**	**0.60**	0.33	**0.67**	**1.00**	**0.60**	**0.67**
Reflection/critical thinking	**1.00**	**0.60**	0.33	**0.67**	0.33	0.40	**0.52**
Application/connections	0.50	**0.60**	0.33	0.00	0.33	0.40	0.38
Self-direction	0.50	0.20	0.00	0.00	0.33	0.20	0.19
Training	0.00	0.20	0.00	0.00	0.00	0.20	0.10
Writing	0.00	0.20	0.33	0.00	0.00	0.00	0.10
Messaging	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CEUs	0.00	0.40	0.00	0.33	**0.67**	0.40	0.33
Collegial	0.50	0.20	0.00	0.00	0.00	0.00	0.10
Exciting	0.00	0.00	0.33	0.00	0.00	0.00	0.05
Important/valuable	0.50	0.20	**0.67**	0.33	0.33	0.20	0.33
Lacking	0.00	0.20	0.00	0.33	0.00	0.20	0.14
Not a priority	0.50	0.00	0.00	0.33	0.00	0.00	0.10
Primacy of patient care	0.00	0.00	0.00	0.00	0.00	0.40	0.10
Requirement/procedural	0.00	0.40	0.33	0.33	0.00	0.40	0.29
Source	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Employer	0.50	0.40	0.33	0.00	0.33	0.40	0.33
Colleagues	0.50	0.00	0.33	0.00	0.00	0.20	0.14
NSGC	0.50	**0.60**	0.33	**1.00**	**0.67**	**0.80**	**0.67**
Profession in general	0.00	0.00	**0.67**	**0.67**	0.00	0.40	0.29
Training programs	0.50	0.20	**0.67**	0.33	0.00	0.20	0.29
Specialization implications	0.00	0.00	0.00	**0.67**	0.00	0.20	0.14
Supportive, provide resources	0.50	**0.80**	0.33	0.33	**0.67**	**1.00**	**0.67**
Opportunities for learning	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Directed learning	0.00	0.20	0.00	0.33	0.00	0.20	0.14

Structured activities, dedicated time	**1.00**	0.40	**0.67**	0.00	0.00	0.40	0.38
Grand rounds/seminars	0.50	0.00	0.33	0.00	0.00	0.20	0.14
Group work	0.50	0.40	0.00	0.33	0.33	0.00	0.24
National conference	0.50	0.40	0.33	**1.00**	**0.67**	0.20	0.48
Frequency	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Constantly	0.00	0.20	0.00	0.33	0.33	0.20	0.19
Daily	0.50	**0.60**	**0.67**	0.33	**0.67**	0.40	**0.52**
Monthly	0.00	0.20	0.33	0.00	0.00	0.00	0.10
Weekly	**1.00**	0.20	0.33	**0.67**	0.33	**0.60**	0.48
Learning by teaching	0.50	0.00	0.33	0.00	0.00	**0.60**	0.24
Precipitants	0.00	0.00	0.00	0.00	0.00	0.00	0.00
New info	0.00	0.40	0.00	**0.67**	0.33	0.20	0.29
New job	0.00	0.20	0.00	0.00	0.00	0.20	0.10
Personal interest	0.50	0.20	0.33	0.00	0.33	0.00	0.19
Practice	**1.00**	**1.00**	**1.00**	**0.67**	**1.00**	**0.60**	**0.86**
Recognized gap in knowledge	**1.00**	0.20	**0.67**	**0.67**	**0.67**	**0.60**	**0.57**
Self-awareness	0.00	0.20	0.00	0.00	0.00	0.00	0.05
Task preparation	0.50	0.00	**0.67**	0.33	0.00	**0.60**	0.33
Online resources	0.50	**0.80**	0.33	**0.67**	0.33	0.00	0.43
Research ideas	0.50	0.00	0.33	0.00	0.33	**0.60**	0.29
Researcher rephrase	**1.00**	**0.60**	**1.00**	**1.00**	**1.00**	**1.00**	**0.90**

Appendix K

Analysis of Influence of Interviewees' Years of Experience

Table 27

Interview Coding by Experience Categories

Years of experience	0-4						5-9								10-14				15+			
Interviewees	Kitty	Susan	Lydia	Lucy	Georgiana	Caroline	Jane	Louisa	Margarette	Marianne	Lizzie	Darcy	Mariah	Julia	Henrietta	Fanny	Charlotte	Betsy	Mary	Elinor	Anne	**Total**
ADVICE																						
Acknowledge limitations						✓		✓														2
Cultivate a formal network	✓		✓		✓		✓	✓	✓			✓		✓				✓				9
Find your passion															✓	✓						2
Cast a wide net		✓		✓						✓					✓	✓			✓	✓	✓	8
Escape the bubble/interdisciplinarity				✓							✓		✓		✓	✓	✓	✓	✓	✓		9
Reflective practice/big picture				✓			✓				✓				✓					✓	✓	6
New job													✓									1
Peruse the literature landscape		✓																	✓			2
Supportive environment					✓	✓																2
Take advantage		✓	✓	✓							✓	✓				✓	✓					7

BROAD THEMES																						
Awareness of not knowing		✓			✓	✓											✓					4
Constant learning	✓	✓	✓	✓		✓	✓		✓					✓	✓	✓	✓		✓		✓	13
Desire vs. require		✓				✓		✓		✓	✓				✓					✓	✓	8
Evolving profession																						0
Perpetually	✓		✓	✓			✓				✓			✓	✓							7
Quickly	✓			✓		✓										✓		✓				5
Formal/informal		✓					✓		✓	✓					✓		✓			✓		7
Interdisciplinarity					✓		✓		✓	✓	✓		✓			✓	✓	✓	✓	✓		11
Learning to learn						✓					✓				✓			✓				4
Networking	✓			✓			✓	✓							✓	✓	✓		✓	✓		9
Protected time		✓		✓		✓																3
Timeliness	✓							✓										✓				3
EVIDENCE OF LEARNING																						
Ability to explain	✓		✓				✓	✓		✓	✓	✓		✓	✓		✓		✓			11
Answer questions	✓									✓							✓					3
Follow-through												✓										1
Patient achieves understanding			✓	✓																		2
Feedback	✓												✓			✓				✓		4
Just do it				✓					✓	✓									✓	✓		5
New perspective/insight		✓											✓	✓		✓					✓	5
Feel prepared	✓						✓				✓											3
Practice makes perfect			✓													✓		✓				3
Saturation				✓	✓		✓		✓						✓							5

LEARNING PROCESS																						
Alternatives																						0
Books				✓		✓				✓								✓				4
Conferences, courses														✓	✓	✓						3
Does not compute				✓	✓				✓	✓	✓											5
Reflection						✓	✓					✓								✓		4
Reworking trusted approaches									✓	✓				✓								3
Someone else					✓					✓	✓	✓				✓		✓				6
Challenges																					✓	1
Access							✓	✓	✓			✓		✓	✓						✓	7
Rate of learning				✓												✓		✓				3
Credentials																		✓		✓		2
Expense				✓			✓		✓					✓			✓		✓		✓	7
Faulty foundation				✓		✓	✓			✓								✓		✓		6
Initiative												✓					✓					2
Lack of specific resources	✓							✓		✓	✓		✓							✓	✓	7
Outdated																	✓			✓		2
Parity																	✓					1
Shared language					✓																	1
Time		✓	✓	✓			✓		✓	✓						✓					✓	8
Competing commitments	✓	✓	✓	✓		✓	✓			✓		✓				✓				✓		10
Prioritizing		✓			✓		✓		✓							✓				✓	✓	7
Colleagues		✓				✓	✓											✓		✓		5
Choice of learning partners													✓									1
Coincidence													✓									1
Alternative perspective	✓			✓						✓	✓	✓			✓			✓		✓	✓	9

Analogy											✓			✓					✓		✓	4
Buy-in																✓						1
Expertise	✓	✓	✓			✓	✓	✓	✓	✓	✓	✓			✓	✓		✓		✓		14
Degree													✓									1
Experience	✓	✓	✓		✓	✓	✓		✓	✓	✓	✓			✓		✓	✓		✓		14
Referral															✓					✓		2
Posting/publishing															✓					✓		2
Role/title	✓	✓			✓			✓	✓	✓	✓		✓			✓		✓		✓	✓	12
Personal connection	✓			✓	✓			✓				✓		✓		✓			✓		✓	9
Respect																✓						1
Personality				✓		✓									✓		✓					4
Judgment						✓			✓													2
Proximity/access				✓	✓			✓	✓						✓			✓			✓	7
Topic/question dependent	✓		✓			✓		✓	✓						✓			✓				7
Collaborative problem-solving			✓	✓		✓	✓		✓		✓					✓	✓	✓		✓	✓	11
Discussion and dialogue	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓		✓	18
Patients				✓		✓							✓									3
Pooling experiences	✓	✓	✓	✓	✓		✓	✓		✓				✓	✓	✓		✓		✓		13
Validation/feedback	✓		✓		✓	✓					✓		✓	✓								7
Critical feedback																✓						1
Conferences			✓			✓			✓										✓			4
Interactivity	✓								✓	✓	✓			✓			✓	✓	✓			8
Mentoring					✓								✓			✓						3
Reading, researching	✓			✓	✓	✓	✓		✓	✓	✓	✓			✓	✓	✓		✓			13
Familiar resources				✓	✓	✓	✓	✓	✓	✓	✓	✓		✓			✓	✓	✓	✓		14
Reflection/critical thinking				✓		✓	✓	✓			✓	✓	✓		✓		✓	✓			✓	11
Application/connections		✓	✓	✓				✓			✓				✓	✓					✓	8

Self-direction				✓							✓	✓			✓							4
Training												✓							✓			2
Writing							✓												✓			2
MESSAGING																						
CEUs			✓					✓	✓	✓		✓								✓	✓	7
Collegial				✓		✓																2
Exciting	✓																					1
Important/valuable	✓			✓		✓	✓			✓						✓				✓		7
Lacking												✓	✓		✓							3
Not a priority													✓				✓					2
Primacy of patient care					✓							✓										2
Requirement/procedural		✓						✓							✓	✓				✓	✓	6
Source																						0
Employer		✓		✓				✓		✓		✓			✓	✓						7
Colleagues	✓			✓										✓								3
NSGC			✓			✓	✓		✓	✓		✓	✓	✓	✓	✓	✓	✓		✓	✓	14
Profession in general	✓	✓			✓							✓	✓					✓				6
Training programs	✓	✓		✓	✓	✓							✓									6
Specialization implications													✓	✓						✓		3
Supportive, provide resources		✓	✓	✓	✓	✓		✓	✓	✓		✓		✓	✓	✓		✓			✓	14
OPPORTUNITIES FOR LEARNING																						
Directed learning												✓	✓		✓							3
Structured activities, dedicated time		✓	✓	✓			✓					✓					✓		✓		✓	8
Grand rounds/seminars		✓														✓	✓					3
Group work			✓					✓			✓						✓			✓		5

National conference			✓				✓	✓	✓	✓			✓				✓	✓		✓	✓	10
Frequency																						0
Constantly										✓			✓	✓	✓							4
Daily	✓					✓	✓		✓	✓			✓		✓	✓	✓		✓		✓	11
Monthly	✓		✓																			2
Weekly		✓	✓	✓	✓						✓	✓					✓	✓		✓	✓	10
Learning by teaching					✓		✓					✓					✓				✓	5
Precipitants																						0
New info			✓					✓	✓				✓			✓				✓		6
New job															✓	✓						2
Personal interest		✓								✓					✓		✓					4
Practice	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓			18
Recognized gap in knowledge	✓			✓	✓	✓	✓		✓	✓		✓					✓	✓		✓	✓	12
Self-awareness															✓							1
Task preparation	✓						✓					✓		✓		✓	✓			✓		7
Online resources		✓	✓			✓		✓		✓			✓				✓	✓	✓			9
Research ideas		✓		✓	✓					✓		✓		✓								6
Researcher rephrase	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	19
SUM	34	32	28	45	29	36	37	28	33	38	30	34	29	25	42	41	36	33	22	38	31	701
N (Documents)	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	21

Table 28

Proportion of Interviewees in Each Experience Category with Statements Relevant to Code

	0-4	5-9	10-14	15+	Total
Advice	0.00	0.00	0.00	0.00	0.00
Acknowledge limitations	0.17	0.13	0.00	0.00	0.10
Cultivate a formal network	0.50	**0.63**	0.25	0.00	0.43
Find your passion	0.00	0.00	0.50	0.00	0.10
Cast a wide net	0.33	0.13	0.50	**1.00**	0.38
Escape the bubble/interdisciplinarity	0.17	0.25	**1.00**	**0.67**	0.43
Reflective practice/big picture	0.17	0.25	0.25	**0.67**	0.29
New job	0.00	0.13	0.00	0.00	0.05
Peruse the literature landscape	0.17	0.00	0.00	0.33	0.10
Supportive environment	0.33	0.00	0.00	0.00	0.10
Take advantage	0.50	0.25	0.50	0.00	0.33
Broad themes	0.00	0.00	0.00	0.00	0.00
Awareness of not knowing	0.50	0.00	0.25	0.00	0.19
Constant learning	**0.83**	0.38	**0.75**	**0.67**	**0.62**
Desire vs. require	0.33	0.38	0.25	**0.67**	0.38
Evolving profession	0.00	0.00	0.00	0.00	0.00
Perpetually	0.50	0.38	0.25	0.00	0.33
Quickly	0.50	0.00	0.50	0.00	0.24
Formal/informal	0.17	0.38	0.50	0.33	0.33
Interdisciplinarity	0.17	**0.63**	**0.75**	**0.67**	**0.52**
Learning to learn	0.17	0.13	0.50	0.00	0.19
Networking	0.33	0.25	**0.75**	**0.67**	0.43
Protected time	0.50	0.00	0.00	0.00	0.14
Timeliness	0.17	0.13	0.25	0.00	0.14
Evidence of learning	0.00	0.00	0.00	0.00	0.00
Ability to explain	0.33	**0.75**	0.50	0.33	**0.52**
Answer questions	0.17	0.13	0.25	0.00	0.14
Follow-through	0.00	0.13	0.00	0.00	0.05
Patient achieves understanding	0.33	0.00	0.00	0.00	0.10
Feedback	0.17	0.13	0.25	0.33	0.19
Just do it	0.17	0.25	0.00	**0.67**	0.24
New perspective/insight	0.17	0.25	0.25	0.33	0.24
Feel prepared	0.17	0.25	0.00	0.00	0.14
Practice makes perfect	0.17	0.00	0.50	0.00	0.14
Saturation	0.33	0.25	0.25	0.00	0.24
Learning process	0.17	0.00	0.25	0.00	0.10

Alternatives	0.00	0.00	0.00	0.00	0.00
Books	0.33	0.13	0.25	0.00	0.19
Conferences, courses	0.00	0.13	0.50	0.00	0.14
Does not compute	0.33	0.38	0.00	0.00	0.24
Reflection	0.17	0.25	0.00	0.33	0.19
Reworking trusted approaches	0.00	0.38	0.00	0.00	0.14
Someone else	0.17	0.38	0.50	0.00	0.29
Challenges	0.00	0.00	0.00	0.33	0.05
Access	0.00	**0.63**	0.25	0.33	0.33
Rate of learning	0.17	0.00	0.50	0.00	0.14
Credentials	0.00	0.00	0.25	0.33	0.10
Expense	0.17	0.38	0.25	**0.67**	0.33
Faulty foundation	0.33	0.25	0.25	0.33	0.29
Initiative	0.00	0.13	0.25	0.00	0.10
Lack of specific resources	0.17	0.50	0.00	**0.67**	0.33
Outdated	0.00	0.00	0.25	0.33	0.10
Parity	0.00	0.00	0.25	0.00	0.05
Shared language	0.17	0.00	0.00	0.00	0.05
Time	0.50	0.38	0.25	0.33	0.38
Competing commitments	**0.83**	0.38	0.25	0.33	0.48
Prioritizing	0.33	0.25	0.25	**0.67**	0.33
Colleagues	0.33	0.13	0.25	0.33	0.24
Choice of learning partners	0.00	0.13	0.00	0.00	0.05
Coincidence	0.00	0.13	0.00	0.00	0.05
Alternative perspective	0.33	0.38	0.50	**0.67**	0.43
Analogy	0.00	0.25	0.00	**0.67**	0.19
Buy-in	0.00	0.00	0.25	0.00	0.05
Expertise	**0.67**	**0.75**	**0.75**	0.33	**0.67**
Degree	0.00	0.13	0.00	0.00	0.05
Experience	**0.83**	**0.63**	**0.75**	0.33	**0.67**
Referral	0.00	0.00	0.25	0.33	0.10
Posting/publishing	0.00	0.00	0.25	0.33	0.10
Role/title	0.50	**0.63**	0.50	**0.67**	**0.57**
Personal connection	0.50	0.38	0.25	**0.67**	0.43
Respect	0.00	0.00	0.25	0.00	0.05
Personality	0.33	0.00	0.50	0.00	0.19
Judgment	0.17	0.13	0.00	0.00	0.10
Proximity/access	0.33	0.25	0.50	0.33	0.33
Topic/question dependent	0.50	0.25	0.50	0.00	0.33
Collaborative problem-solving	0.50	0.38	**0.75**	**0.67**	**0.52**
Discussion and dialogue	**0.83**	**1.00**	**0.75**	**0.67**	**0.86**

Patients	0.33	0.13	0.00	0.00	0.14
Pooling experiences	**0.83**	0.50	**0.75**	0.33	**0.62**
Validation/feedback	**0.67**	0.38	0.00	0.00	0.33
Critical feedback	0.00	0.00	0.25	0.00	0.05
Conferences	0.33	0.13	0.00	0.33	0.19
Interactivity	0.17	0.50	0.50	0.33	0.38
Mentoring	0.17	0.13	0.25	0.00	0.14
Reading, researching	**0.67**	**0.63**	**0.75**	0.33	**0.62**
Familiar resources	0.50	**0.88**	0.50	**0.67**	**0.67**
Reflection/critical thinking	0.33	**0.63**	**0.75**	0.33	**0.52**
Application/connections	0.50	0.25	0.50	0.33	0.38
Self-direction	0.17	0.25	0.25	0.00	0.19
Training	0.00	0.13	0.00	0.33	0.10
Writing	0.00	0.13	0.00	0.33	0.10
Messaging	0.00	0.00	0.00	0.00	0.00
CEUs	0.17	0.50	0.00	**0.67**	0.33
Collegial	0.33	0.00	0.00	0.00	0.10
Exciting	0.17	0.00	0.00	0.00	0.05
Important/valuable	0.50	0.25	0.25	0.33	0.33
Lacking	0.00	0.25	0.25	0.00	0.14
Not a priority	0.00	0.13	0.25	0.00	0.10
Primacy of patient care	0.17	0.13	0.00	0.00	0.10
Requirement/procedural	0.17	0.13	0.50	**0.67**	0.29
Source	0.00	0.00	0.00	0.00	0.00
Employer	0.33	0.38	0.50	0.00	0.33
Colleagues	0.33	0.13	0.00	0.00	0.14
NSGC	0.33	**0.75**	**1.00**	**0.67**	**0.67**
Profession in general	0.50	0.25	0.25	0.00	0.29
Training programs	**0.83**	0.13	0.00	0.00	0.29
Specialization implications	0.00	0.25	0.00	0.33	0.14
Supportive, provide resources	**0.83**	**0.63**	**0.75**	0.33	**0.67**
Opportunities for learning	0.00	0.00	0.00	0.00	0.00
Directed learning	0.00	0.25	0.25	0.00	0.14
Structured activities, dedicated time	0.50	0.25	0.25	**0.67**	0.38
Grand rounds/seminars	0.17	0.00	0.50	0.00	0.14
Group work	0.17	0.25	0.25	0.33	0.24
National conference	0.17	**0.63**	0.50	**0.67**	0.48
Frequency	0.00	0.00	0.00	0.00	0.00
Constantly	0.00	0.38	0.25	0.00	0.19
Daily	0.33	0.50	**0.75**	**0.67**	**0.52**
Monthly	0.33	0.00	0.00	0.00	0.10

Weekly	**0.67**	0.25	0.50	**0.67**	0.48
Learning by teaching	0.17	0.25	0.25	0.33	0.24
Precipitants	0.00	0.00	0.00	0.00	0.00
New info	0.17	0.38	0.25	0.33	0.29
New job	0.00	0.00	0.50	0.00	0.10
Personal interest	0.17	0.13	0.50	0.00	0.19
Practice	**1.00**	**0.88**	**1.00**	0.33	**0.86**
Recognized gap in knowledge	**0.67**	0.50	0.50	**0.67**	**0.57**
Self-awareness	0.00	0.00	0.25	0.00	0.05
Task preparation	0.17	0.38	0.50	0.33	0.33
Online resources	0.50	0.38	0.50	0.33	0.43
Research ideas	0.50	0.38	0.00	0.00	0.29
Researcher rephrase	**0.83**	**1.00**	**1.00**	**0.67**	**0.90**

Appendix L

Analysis of Influence of Interviewees' Ambiguity Tolerance

Table 29

Interview Coding by Ambiguity Tolerance Categories

Ambiguity tolerance score	**< 55**			**55 – 61**					**62-67**						**>67**					
Interviewees	Susan	Margarette	Lizzie	Charlotte	Caroline	Lydia	Louisa	Darcy	Mary	Betsy	Elinor	Marianne	Georgiana	Julia	Henrietta	Kitty	Jane	Fanny	Anne	**Total**
ADVICE																				
Acknowledge limitations					✓		✓													2
Cultivate a formal network		✓				✓	✓	✓		✓			✓	✓		✓	✓			9
Find your passion															✓			✓		2
Cast a wide net	✓								✓		✓	✓			✓			✓	✓	7
Escape the bubble/interdisciplinarity			✓	✓					✓	✓	✓				✓			✓		7
Reflective practice/big picture			✓								✓				✓		✓		✓	5
New job																				0
Peruse the literature landscape	✓								✓											2
Supportive environment					✓								✓							2
Take advantage	✓		✓	✓		✓		✓										✓		6

BROAD THEMES																				
Awareness of not knowing	✓			✓	✓								✓							4
Constant learning	✓	✓		✓	✓	✓			✓					✓	✓	✓	✓	✓	✓	12
Desire vs. require	✓		✓		✓		✓				✓	✓			✓				✓	8
Evolving profession																				0
Perpetually			✓			✓								✓	✓	✓	✓			6
Quickly					✓					✓						✓		✓		4
Formal/informal	✓	✓		✓							✓	✓			✓		✓			7
Interdisciplinarity		✓	✓	✓					✓	✓	✓	✓	✓				✓	✓		10
Learning to learn			✓		✓					✓					✓					4
Networking				✓			✓		✓		✓				✓	✓	✓	✓		8
Protected time	✓				✓															2
Timeliness							✓			✓						✓				3
EVIDENCE OF LEARNING																				
Ability to explain			✓	✓		✓	✓	✓	✓			✓		✓	✓	✓	✓			11
Answer questions				✓								✓				✓				3
Follow-through								✓												1
Patient achieves understanding						✓														1
Feedback											✓					✓		✓		3
Just do it		✓							✓		✓	✓								4
New perspective/insight	✓													✓				✓	✓	4
Feel prepared			✓													✓	✓			3
Practice makes perfect						✓				✓								✓		3
Saturation		✓											✓		✓		✓			4

LEARNING PROCESS																				
Alternatives																				0
Books					✓					✓		✓								3
Conferences, courses														✓	✓			✓		3
Does not compute		✓	✓									✓	✓							4
Reflection					✓			✓			✓						✓			4
Reworking trusted approaches		✓										✓		✓						3
Someone else			✓					✓		✓		✓	✓					✓		6
Challenges																			✓	1
Access		✓					✓	✓						✓	✓		✓		✓	7
Rate of learning										✓								✓		2
Credentials										✓	✓									2
Expense		✓		✓					✓					✓			✓		✓	6
Faulty foundation					✓					✓	✓	✓					✓			5
Initiative				✓				✓												2
Lack of specific resources			✓				✓				✓	✓				✓			✓	6
Outdated				✓							✓									2
Parity				✓																1
Shared language													✓							1
Time	✓	✓				✓						✓					✓	✓	✓	7
Competing commitments	✓				✓	✓		✓			✓	✓				✓	✓	✓		9
Prioritizing	✓	✓									✓		✓				✓	✓	✓	7
Colleagues	✓				✓					✓	✓						✓			5
Choice of learning partners																				0
Coincidence																				0
Alternative perspective			✓					✓		✓	✓	✓			✓	✓			✓	8

Analogy			✓						✓					✓					✓	4
Buy-in																		✓		1
Expertise	✓	✓	✓		✓	✓	✓	✓		✓	✓	✓			✓	✓	✓	✓		14
Degree																				0
Experience	✓	✓	✓	✓	✓	✓		✓		✓	✓	✓	✓		✓	✓	✓			14
Referral											✓				✓					2
Posting/publishing											✓				✓					2
Role/title	✓	✓	✓				✓			✓	✓	✓	✓			✓		✓	✓	11
Personal connection							✓	✓	✓				✓	✓		✓		✓	✓	8
Respect																		✓		1
Personality				✓	✓										✓					3
Judgment		✓			✓															2
Proximity/access		✓					✓			✓			✓		✓				✓	6
Topic/question dependent		✓			✓	✓	✓			✓					✓	✓				7
Collaborative problem-solving		✓	✓	✓	✓	✓				✓	✓						✓	✓	✓	10
Discussion and dialogue	✓	✓	✓	✓	✓		✓	✓	✓			✓	✓	✓	✓	✓	✓	✓	✓	16
Patients					✓															1
Pooling experiences	✓					✓	✓			✓	✓	✓	✓	✓	✓	✓	✓	✓		12
Validation/feedback			✓		✓	✓							✓	✓		✓				6
Critical feedback																		✓		1
Conferences		✓			✓	✓			✓											4
Interactivity		✓	✓	✓					✓	✓		✓		✓		✓				8
Mentoring													✓					✓		2
Reading, researching		✓	✓	✓	✓			✓	✓			✓	✓		✓	✓	✓	✓		12
Familiar resources		✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓			✓			13
Reflection/critical thinking			✓	✓	✓		✓	✓		✓					✓		✓		✓	9
Application/connections	✓		✓			✓	✓								✓			✓	✓	7

Self-direction			✓					✓							✓					3
Training								✓	✓											2
Writing									✓								✓			2
MESSAGING																				
CEUs		✓				✓	✓	✓			✓	✓							✓	7
Collegial					✓															1
Exciting																✓				1
Important/valuable					✓						✓	✓				✓	✓	✓		6
Lacking								✓							✓					2
Not a priority				✓																1
Primacy of patient care								✓					✓							2
Requirement/procedural	✓						✓				✓				✓			✓	✓	6
Source																				0
Employer	✓						✓	✓				✓			✓			✓		6
Colleagues														✓		✓				2
NSGC		✓		✓	✓	✓		✓		✓	✓	✓		✓	✓		✓	✓	✓	13
Profession in general	✓							✓		✓			✓			✓				5
Training programs	✓				✓								✓			✓				4
Specialization implications											✓			✓						2
Supportive, provide resources	✓	✓			✓	✓	✓	✓		✓		✓	✓	✓	✓			✓	✓	13
OPPORTUNITIES FOR LEARNING																				
Directed learning								✓							✓					2
Structured activities, dedicated time	✓			✓		✓		✓	✓								✓		✓	7
Grand rounds/seminars	✓			✓														✓		3
Group work			✓	✓		✓	✓				✓									5
National conference		✓		✓		✓	✓			✓	✓	✓					✓		✓	9
Frequency																				0

Constantly												✓		✓	✓					3
Daily		✓		✓	✓				✓			✓			✓	✓	✓	✓	✓	10
Monthly						✓										✓				2
Weekly	✓		✓	✓		✓		✓		✓	✓		✓						✓	9
Learning by teaching				✓				✓					✓				✓		✓	5
Precipitants																				0
New info		✓				✓	✓				✓							✓		5
New job															✓			✓		2
Personal interest	✓			✓								✓			✓					4
Practice	✓	✓	✓	✓	✓	✓	✓		✓	✓		✓	✓	✓	✓	✓	✓	✓		16
Recognized gap in knowledge		✓		✓	✓			✓		✓	✓	✓	✓			✓	✓		✓	11
Self-awareness															✓					1
Task preparation				✓				✓			✓			✓		✓	✓	✓		7
Online resources	✓			✓	✓	✓	✓		✓	✓		✓								8
Research ideas	✓							✓				✓	✓	✓						5
Researcher rephrase	✓	✓	✓	✓	✓		✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	17
SUM	32	33	30	36	36	28	28	34	22	33	38	38	29	25	41	34	37	41	31	626
N documents	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	19

Table 30

Proportion of Interviewees in Each Ambiguity Tolerance Category with Statements Relevant to Code

	< 55	55-61	62-67	> 67	TOTAL
ADVICE					
Acknowledge limitations	0.00	0.40	0.00	0.00	0.11
Cultivate a formal network	0.33	**0.60**	0.50	0.40	0.47
Find your passion	0.00	0.00	0.00	0.40	0.11
Cast a wide net	0.33	0.00	0.50	**0.60**	0.37
Escape the bubble/interdisciplinarity	0.33	0.20	0.50	0.40	0.37
Reflective practice/big picture	0.33	0.00	0.17	**0.60**	0.26
New job	0.00	0.00	0.00	0.00	0.00
Peruse the literature landscape	0.33	0.00	0.17	0.00	0.11
Supportive environment	0.00	0.20	0.17	0.00	0.11
Take advantage	**0.67**	**0.60**	0.00	0.20	0.32
BROAD THEMES					
Awareness of not knowing	0.33	0.40	0.17	0.00	0.21
Constant learning	**0.67**	**0.60**	0.33	**1.00**	**0.63**
Desire vs. require	**0.67**	0.40	0.33	0.40	0.42
Evolving profession	0.00	0.00	0.00	0.00	0.00
Perpetually	0.33	0.20	0.17	**0.60**	0.32
Quickly	0.00	0.20	0.17	0.40	0.21
Formal/informal	**0.67**	0.20	0.33	0.40	0.37
Interdisciplinarity	**0.67**	0.20	**0.83**	0.40	0.53
Learning to learn	0.33	0.20	0.17	0.20	0.21
Networking	0.00	0.40	0.33	**0.80**	0.42
Protected time	0.33	0.20	0.00	0.00	0.11
Timeliness	0.00	0.20	0.17	0.20	0.16
EVIDENCE OF LEARNING					
Ability to explain	0.33	**0.80**	0.50	**0.60**	0.58
Answer questions	0.00	0.20	0.17	0.20	0.16
Follow-through	0.00	0.20	0.00	0.00	0.05
Patient achieves understanding	0.00	0.20	0.00	0.00	0.05
Feedback	0.00	0.00	0.17	0.40	0.16
Just do it	0.33	0.00	0.50	0.00	0.21
New perspective/insight	0.33	0.00	0.17	0.40	0.21
Feel prepared	0.33	0.00	0.00	0.40	0.16
Practice makes perfect	0.00	0.20	0.17	0.20	0.16

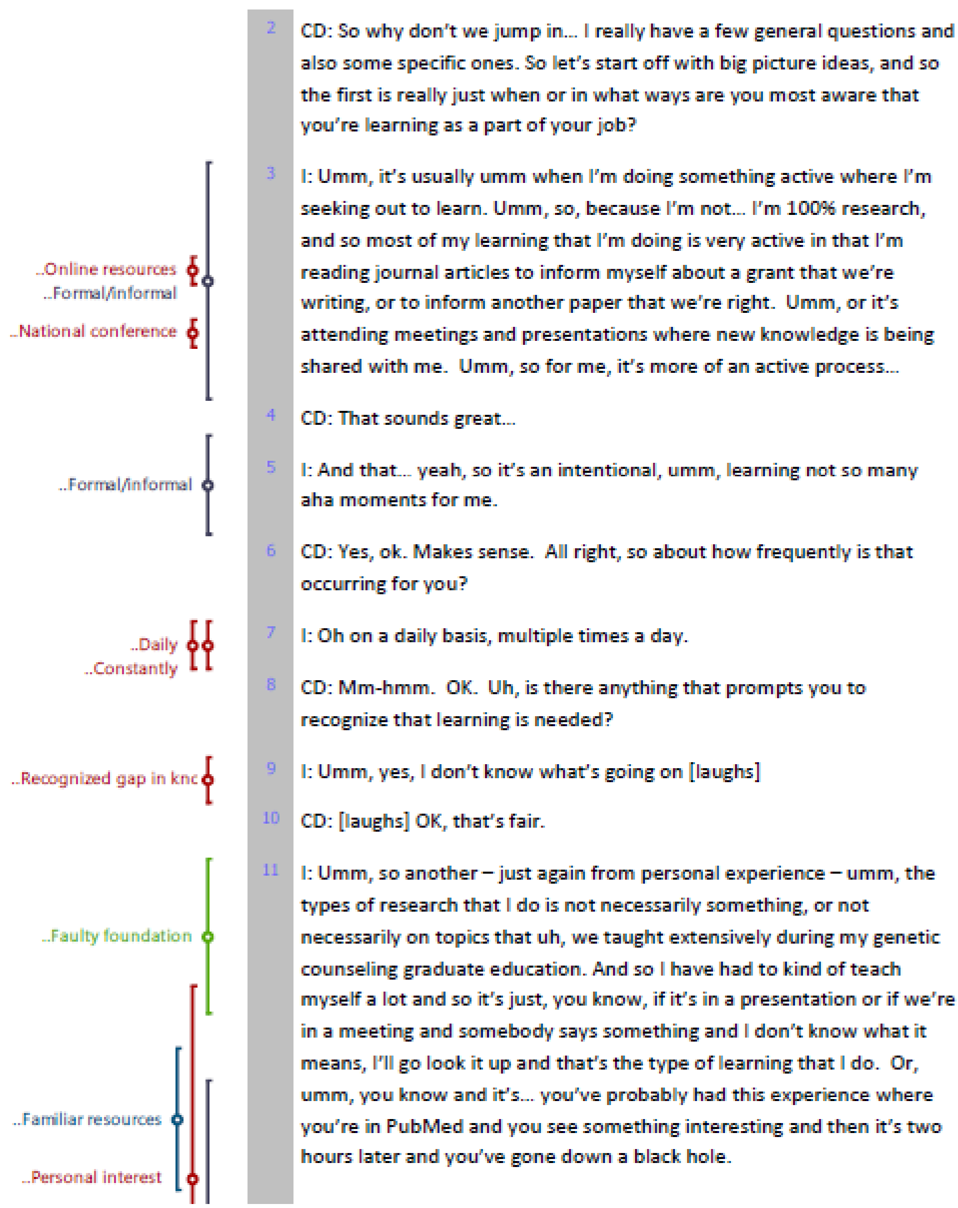
Saturation	0.33	0.00	0.17	0.40	0.21
LEARNING PROCESS					
Alternatives	0.00	0.00	0.00	0.00	0.00
Books	0.00	0.20	0.33	0.00	0.16
Conferences, courses	0.00	0.00	0.17	0.40	0.16
Does not compute	**0.67**	0.00	0.33	0.00	0.21
Reflection	0.00	0.40	0.17	0.20	0.21
Reworking trusted approaches	0.33	0.00	0.33	0.00	0.16
Someone else	0.33	0.20	0.50	0.20	0.32
Challenges	0.00	0.00	0.00	0.20	0.05
Access	0.33	0.40	0.17	**0.60**	0.37
Rate of learning	0.00	0.00	0.17	0.20	0.11
Credentials	0.00	0.00	0.33	0.00	0.11
Expense	0.33	0.20	0.33	0.40	0.32
Faulty foundation	0.00	0.20	0.50	0.20	0.26
Initiative	0.00	0.40	0.00	0.00	0.11
Lack of specific resources	0.33	0.20	0.33	0.40	0.32
Outdated	0.00	0.20	0.17	0.00	0.11
Parity	0.00	0.20	0.00	0.00	0.05
Shared language	0.00	0.00	0.17	0.00	0.05
Time	**0.67**	0.20	0.17	**0.60**	0.37
Competing commitments	0.33	**0.60**	0.33	**0.60**	0.47
Prioritizing	**0.67**	0.00	0.33	**0.60**	0.37
Colleagues	0.33	0.20	0.33	0.20	0.26
Choice of learning partners	0.00	0.00	0.00	0.00	0.00
Coincidence	0.00	0.00	0.00	0.00	0.00
Alternative perspective	0.33	0.20	0.50	**0.60**	0.42
Analogy	0.33	0.00	0.33	0.20	0.21
Buy-in	0.00	0.00	0.00	0.20	0.05
Expertise	**1.00**	**0.80**	0.50	**0.80**	**0.74**
Degree	0.00	0.00	0.00	0.00	0.00
Experience	**1.00**	**0.80**	**0.67**	**0.60**	**0.74**
Referral	0.00	0.00	0.17	0.20	0.11
Posting/publishing	0.00	0.00	0.17	0.20	0.11
Role/title	**1.00**	0.20	**0.67**	**0.60**	0.58
Personal connection	0.00	0.40	0.50	**0.60**	0.42
Respect	0.00	0.00	0.00	0.20	0.05
Personality	0.00	0.40	0.00	0.20	0.16
Judgment	0.33	0.20	0.00	0.00	0.11
Proximity/access	0.33	0.20	0.33	0.40	0.32
Topic/question dependent	0.33	**0.60**	0.17	0.40	0.37

Collaborative problem-solving	**0.67**	**0.60**	0.33	**0.60**	0.53
Discussion and dialogue	**1.00**	**0.80**	**0.67**	**1.00**	**0.84**
Patients	0.00	0.20	0.00	0.00	0.05
Pooling experiences	0.33	0.40	**0.83**	**0.80**	**0.63**
Validation/feedback	0.33	0.40	0.33	0.20	0.32
Critical feedback	0.00	0.00	0.00	0.20	0.05
Conferences	0.33	0.40	0.17	0.00	0.21
Interactivity	**0.67**	0.20	**0.67**	0.20	0.42
Mentoring	0.00	0.00	0.17	0.20	0.11
Reading, researching	**0.67**	**0.60**	0.50	**0.80**	**0.63**
Familiar resources	**0.67**	**0.80**	**1.00**	0.20	**0.68**
Reflection/critical thinking	0.33	**0.80**	0.17	**0.60**	0.47
Application/connections	**0.67**	0.40	0.00	**0.60**	0.37
Self-direction	0.33	0.20	0.00	0.20	0.16
Training	0.00	0.20	0.17	0.00	0.11
Writing	0.00	0.00	0.17	0.20	0.11
MESSAGING					
CEUs	0.33	**0.60**	0.33	0.20	0.37
Collegial	0.00	0.20	0.00	0.00	0.05
Exciting	0.00	0.00	0.00	0.20	0.05
Important/valuable	0.00	0.20	0.33	**0.60**	0.32
Lacking	0.00	0.20	0.00	0.20	0.11
Not a priority	0.00	0.20	0.00	0.00	0.05
Primacy of patient care	0.00	0.20	0.17	0.00	0.11
Requirement/procedural	0.33	0.20	0.17	**0.60**	0.32
Source	0.00	0.00	0.00	0.00	0.00
Employer	0.33	0.40	0.17	0.40	0.32
Colleagues	0.00	0.00	0.17	0.20	0.11
NSGC	0.33	**0.80**	**0.67**	**0.80**	**0.68**
Profession in general	0.33	0.20	0.33	0.20	0.26
Training programs	0.33	0.20	0.17	0.20	0.21
Specialization implications	0.00	0.00	0.33	0.00	0.11
Supportive, provide resources	**0.67**	**0.80**	**0.67**	**0.60**	**0.68**
OPPORTUNITIES FOR LEARNING					
Directed learning	0.00	0.20	0.00	0.20	0.11
Structured activities, dedicated time	0.33	**0.60**	0.17	0.40	0.37
Grand rounds/seminars	0.33	0.20	0.00	0.20	0.16
Group work	0.33	**0.60**	0.17	0.00	0.26
National conference	0.33	**0.60**	0.50	0.40	0.47
Frequency	0.00	0.00	0.00	0.00	0.00
Constantly	0.00	0.00	0.33	0.20	0.16

Daily	0.33	0.40	0.33	**1.00**	0.53
Monthly	0.00	0.20	0.00	0.20	0.11
Weekly	**0.67**	**0.60**	0.50	0.20	0.47
Learning by teaching	0.00	0.40	0.17	0.40	0.26
Precipitants	0.00	0.00	0.00	0.00	0.00
New info	0.33	0.40	0.17	0.20	0.26
New job	0.00	0.00	0.00	0.40	0.11
Personal interest	0.33	0.20	0.17	0.20	0.21
Practice	**1.00**	**0.80**	**0.83**	**0.80**	**0.84**
Recognized gap in knowledge	0.33	**0.60**	**0.67**	**0.60**	0.58
Self-awareness	0.00	0.00	0.00	0.20	0.05
Task preparation	0.00	0.40	0.33	**0.60**	0.37
Online resources	0.33	**0.80**	0.50	0.00	0.42
Research ideas	0.33	0.20	0.50	0.00	0.26
Researcher rephrase	**1.00**	**0.80**	**0.83**	**1.00**	**0.89**

Appendix M

Excerpt from Coded Interview Transcript



2 CD: So why don't we jump in… I really have a few general questions and also some specific ones. So let's start off with big picture ideas, and so the first is really just when or in what ways are you most aware that you're learning as a part of your job?

3 I: Umm, it's usually umm when I'm doing something active where I'm seeking out to learn. Umm, so, because I'm not… I'm 100% research, and so most of my learning that I'm doing is very active in that I'm reading journal articles to inform myself about a grant that we're writing, or to inform another paper that we're right. Umm, or it's attending meetings and presentations where new knowledge is being shared with me. Umm, so for me, it's more of an active process…

4 CD: That sounds great…

5 I: And that… yeah, so it's an intentional, umm, learning not so many aha moments for me.

6 CD: Yes, ok. Makes sense. All right, so about how frequently is that occurring for you?

7 I: Oh on a daily basis, multiple times a day.

8 CD: Mm-hmm. OK. Uh, is there anything that prompts you to recognize that learning is needed?

9 I: Umm, yes, I don't know what's going on [laughs]

10 CD: [laughs] OK, that's fair.

11 I: Umm, so another – just again from personal experience – umm, the types of research that I do is not necessarily something, or not necessarily on topics that uh, we taught extensively during my genetic counseling graduate education. And so I have had to kind of teach myself a lot and so it's just, you know, if it's in a presentation or if we're in a meeting and somebody says something and I don't know what it means, I'll go look it up and that's the type of learning that I do. Or, umm, you know and it's… you've probably had this experience where you're in PubMed and you see something interesting and then it's two hours later and you've gone down a black hole.

Image 3. Excerpt of coded interview transcript.

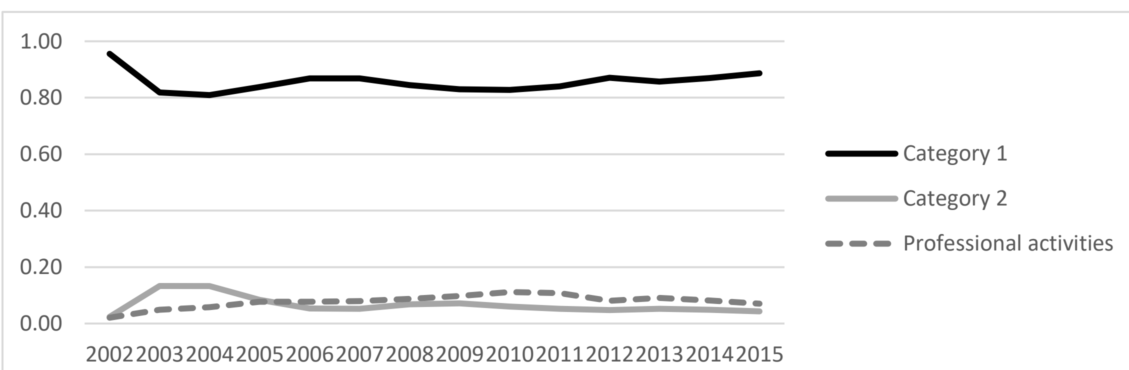
Appendix N

Continuing Education Unit Database Summary Statistics

Table 31

Continuing Education Unit (CEU) Database Credit Summary by Category, 2002-2015

YEAR	Category 1 credits	% Category 1 credits	Category 2 credits	% Category 2 credits	Professional Activity credits	% Professional Activity credits	Total credits per year
2002	378.21	0.96	9.4	0.02	8.2	0.02	395.81
2003	749.56	0.82	121.82	0.13	44.8	0.05	916.18
2004	727.18	0.81	118.82	0.13	52.45	0.06	898.45
2005	1010.48	0.84	101.71	0.08	93.6	0.08	1205.79
2006	1580.59	0.87	98.08	0.05	141.35	0.08	1820.02
2007	2016.58	0.87	120.55	0.05	184.45	0.08	2321.58
2008	2266.67	0.84	183.65	0.07	234.22	0.09	2684.54
2009	2126.79	0.83	184.57	0.07	251.21	0.10	2562.57
2010	3310.54	0.83	242.29	0.06	446.15	0.11	3998.98
2011	3976.35	0.84	245.45	0.05	509.91	0.11	4731.71
2012	4956.99	0.87	273.19	0.05	460.32	0.08	5690.5
2013	4523.32	0.86	277.4	0.05	478.49	0.09	5279.21
2014	5153.9	0.87	292.56	0.05	482.76	0.08	5929.22
2015	4425.31	0.89	216.64	0.04	349.97	0.07	4991.92
TOTAL	37202.47	0.86	2486.13	0.07	3737.88	0.08	43426.48



Graph 4. Relative proportions of category 1, 2, and professional activity credits, 2002-2015.

Table 32

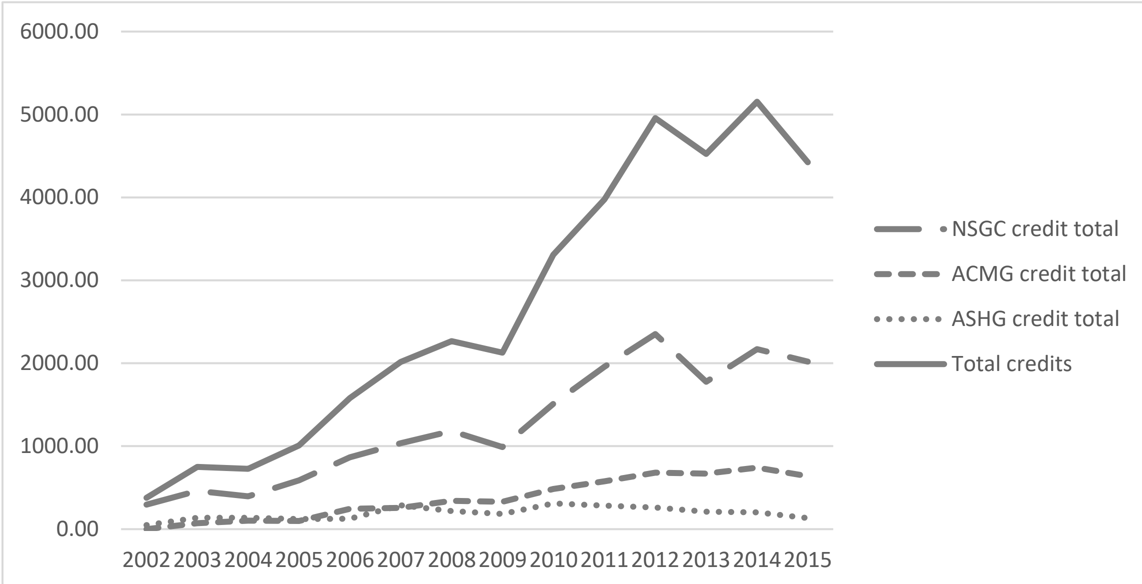
Category 1 Credit Summary by Total, In-person, and Online Credits

YEAR	# entries	credits	# in-person	credits in-person	% in-person	# online	credits online	% online
2002	204	378.21	204	378.21	1.00	0	0	0.00
2003	443	749.56	443	749.56	1.00	0	0	0.00
2004	457	727.18	457	727.18	1.00	0	0	0.00
2005	622	1010.48	615	994.21	0.98	7	16.27	0.02
2006	998	1580.59	971	1503.03	0.95	27	77.56	0.05
2007	1224	2016.58	1167	1853.71	0.92	57	162.87	0.08
2008	1602	2266.67	1426	2029.67	0.90	176	237	0.10
2009	1817	2126.79	1210	1721.21	0.81	607	405.58	0.19
2010	2732	3310.54	1757	2652.52	0.80	975	658.02	0.20
2011	3711	3976.35	2088	3030.26	0.76	1623	946.09	0.24
2012	4710	4956.99	2291	3437.72	0.69	2419	1519.27	0.31
2013	3950	4523.32	2576	3364.53	0.74	1374	1158.79	0.26
2014	6062	5153.9	2676	3429.75	0.67	3386	1724.15	0.33
2015	6097	4425.31	2289	2815.74	0.64	3808	1609.57	0.36
TOTAL	**34629**	**37292.47**	**20170**	**28687.30**	**0.77**	**14459**	**8515.17**	**0.23**

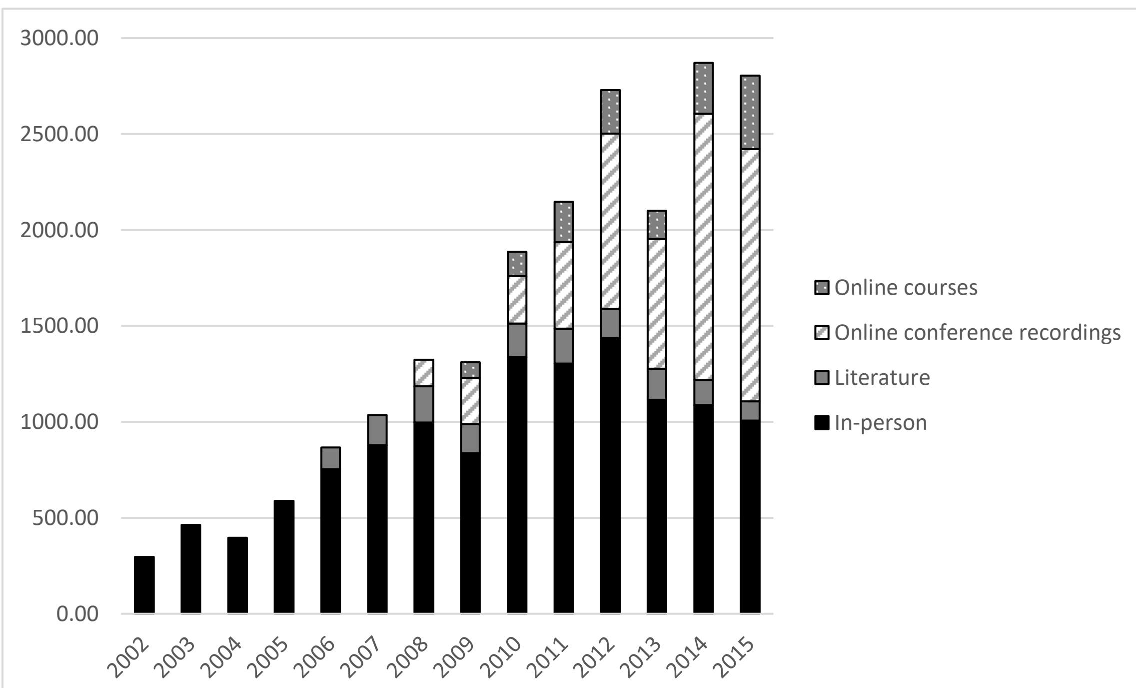
Table 33

Top Providers of Category 1 Credits (by Credit Total)

Provider name	# of entries	Credits (% of total)	Organization type
National Society of Genetic Counselors (NSGC)	18952	17613.46 (47)	Professional society
American College of Medical Genetics (ACMG)	2315	5241.82 (14)	Professional society
American Society of Human Genetics (ASHG)	1199	2665.00 (7)	Professional society
University of Pennsylvania	533	2327.89 (6)	GC training program
Canadian Association of Genetic Counsellors (CAGC)	403	658.19 (2)	Professional society
Collaborative Group of the Americas – Inherited Colorectal Cancer (CGA-ICC)	473	614.03 (2)	Professional society
City of Hope National Medical Center	97	476.42 (1)	Medical center
Arcadia University	121	406.43 (1)	GC training program
University of Cincinnati	241	390.60 (1)	GC training program
New England Regional Genetics Group (NERGG)	302	284.50 (1)	Professional group
Minnesota Genetic Counselors Association (MNGCA)	406	272.08 (1)	Professional group
International Society for Prenatal Diagnosis (ISPD)	142	271.03 (1)	Professional society



Graph 5. Comparison of credit totals from top three category 1 credit providers.



Graph 6. National Society of Genetic Counselors (NSGC)-sponsored category 1 credit activities, 2002-2015.

Table 34

Professional Activity Credits by Number of Entries, Credit Total, and Proportions by Type

Professional activity	# entries	# credits	% total PACs
Publication	1617	1613.8	0.43
Clinical supervision	1787	1030.16	0.28
Teaching	505	370.93	0.10
Leadership activities to a genetics-related organization	227	223.36	0.06
Volunteer service to genetics-related organization	135	115.39	0.03
Presentation to professionals	950	113.28	0.03
Genetics education outreach	543	90.66	0.02
Undergraduate or graduate coursework	32	81.4	0.02
Peer review of manuscripts	87	29.9	0.01
Patient education publications	74	25.52	0.01
Non-peer reviewed publications	44	21	0.01
Volunteer at a chronic disease specialty camp	17	11.8	0.00
Peer supervision groups	42	10.68	0.00
TOTAL	**6060**	**3737.88**	**1.00**

Appendix O

IRB Approval Letter

TEACHERS COLLEGE
COLUMBIA UNIVERSITY

Teachers College IRB — **Approval Notification**

To: Claire Davis
From: Karen Froud, IRB Chair
Subject: IRB Approval: 15-393 Protocol
Date: 08/19/2015

Please be informed that as of the date of this letter, the Institutional Review Board for the Protection of Human Subjects at Teachers College, Columbia University has given full approval to your study, entitled "*Incorporating innovations into practice: The professional learning of genetic counselors*," under **Expedited Review** (Category **(7) Research on individual or group characteristics or behavior**).

The approval is effective until **08/18/2016**.

The IRB Committee must be contacted if there are any changes to the protocol during this period. **Please note:** If you are planning to continue your study, a Continuing Review report must be submitted to either close the protocol or request permission to continue for another year. Please submit your report by **07/21/2016** so that the IRB has time to review and approve your report if you wish to continue your study. The IRB number assigned to your protocol is **15-393**. Feel free to contact the IRB Office (212-678-4105 or irb@tc.columbia.edu) if you have any questions.

Please note that your Consent form bears an official IRB authorization stamp. Copies of this form with the IRB stamp must be used for your research work. Further, all research recruitment materials must include the study's IRB-approved protocol number. You can retrieve a PDF copy of this approval letter as well as the stamped consent(s) and recruitment materials from the IRB Mentor site.

When your study ends, please visit the IRB Mentor site. Go to the Continuing Review tab and select "terminate" from the drop-down menu.

Best wishes for your research work.

Sincerely,

Karen Froud, Ph.D.
Associate Professor of Neuroscience & Education
IRB Chair

Image 4. Teachers College Institutional Review Board approval letter.

Appendix P

Research Description and Implied Consent Statement (Critical Incident Questionnaire)

Teachers College, Columbia University
525 West 120th Street
New York NY 10027
212 678 3000
www.tc.edu

Principal Investigator: Claire Davis, MS, CGC
Research Title: Incorporating innovations into practice: The professional learning of genetic counselors

INFORMED CONSENT

DESCRIPTION OF THE RESEARCH: You are invited to participate in a research study on the professional learning of genetic counselors. This study will explore your thoughts on professional learning, particularly learning that occurs in response to scientific innovation, as well as the learning strategies and resources you find helpful. The purpose of this study is to better understand the professional learning of genetic counselors. You will be asked to fill out a questionnaire. The research will be conducted by Claire Davis, MS, CGC. The research will be conducted online.

RISKS AND BENEFITS: The risks associated with this study are feelings of discomfort or guilt when considering your professional development and learning. Participants are not expected to derive direct benefit from participating. Participation in this study is completely voluntary. You may stop participation at any time or skip any questions you do not wish to answer.

DATA STORAGE TO PROTECT CONFIDENTIALITY: All responses will be stored in password-protected files on the researcher's personal computer, which is also password-protected. All data will be de-identified prior to analysis and publication.

TIME INVOLVEMENT: Your participation will take approximately 20 minutes.

HOW WILL RESULTS BE USED: The results of the study will be used to complete the researcher's dissertation and may be presented at conferences, published in articles, or used for educational purposes.

PARTICIPANT'S RIGHTS

- I have read the Research Description.
- My participation in research is voluntary. I may refuse to participate or withdraw from participation at any time without jeopardy to future medical care, employment, student status or other entitlements.
- The researcher may withdraw me from the research at her discretion.
- Any information derived from the research project that personally identifies me will not be voluntarily released or disclosed without my separate consent, except as specifically required by law.
- If at any time I have any questions regarding the research or my participation, I can contact the investigator, who will answer my questions. The investigator's phone number is (206) 234-7277.
- If at any time I have comments or concerns regarding the conduct of the research or questions about my rights as a research subject, I should contact the Teachers College, Columbia University Institutional Review Board /IRB. The phone number for the IRB is (212) 678-4105. Or, I can write to the IRB at Teachers College, Columbia University, 525 W. 120th Street, New York, NY, 10027, Box 151.
- I may request and will receive a copy of the Research Description and this Participant's Rights document.

By clicking “Next", I agree that I have read the above and wish to participate in this study.

Appendix Q

Subject Consent Form (Interview)

Teachers College, Columbia University
525 West 120th Street
New York NY 10027
212 678 3000
www.tc.edu

Principal Investigator: Claire Davis, MS, CGC
Research Title: Incorporating innovations into practice: The professional learning of genetic counselors

INFORMED CONSENT

DESCRIPTION OF THE RESEARCH: You are invited to participate in a research study on the professional learning of genetic counselors. This study will explore your thoughts on professional learning, particularly learning that occurs in response to scientific innovation, as well as the learning strategies and resources you find helpful. The purpose of this study is to better understand the professional learning of genetic counselors. You will be asked to participate in an interview. The research will be conducted by Claire Davis, MS, CGC. The research will be conducted in person or over the phone.

RISKS AND BENEFITS: The risks associated with this study are feelings of discomfort or guilt when considering your professional development and learning. Participants are not expected to derive direct benefit from participating. Participation in this study is completely voluntary. You may stop participation at any time or skip any questions you do not wish to answer.

DATA STORAGE TO PROTECT CONFIDENTIALITY: All interviews will be transcribed and the recordings and transcripts will be stored in password-protected files on the researcher's personal computer, which is also password-protected. All data will be de-identified prior to analysis and publication.

TIME INVOLVEMENT: Your participation will take approximately one hour.

HOW WILL RESULTS BE USED: The results of the study will support the completion of the researcher's dissertation and may be presented at conferences, published in articles, or used for educational purposes.

PARTICIPANT'S RIGHTS

- I have discussed the Research Description with the researcher. I have had the opportunity to ask questions about the purposes and procedures regarding this study.
- My participation in research is voluntary. I may refuse to participate or withdraw from participation at any time without jeopardy to future medical care, employment, student status or other entitlements.
- The researcher may withdraw me from the research at her discretion.
- If, during the course of the study, significant new information that has been developed becomes available which may relate to my willingness to continue to participate, the investigator will provide this information to me.
- Any information derived from the research project that personally identifies me will not be voluntarily released or disclosed without my separate consent, except as specifically required by law.
- If at any time I have any questions regarding the research or my participation, I can contact the investigator, who will answer my questions. The investigator's phone number is (206) 234-7277.
- If at any time I have comments or concerns regarding the conduct of the research or questions about my rights as a research subject, I should contact the Teachers College, Columbia University Institutional Review Board /IRB. The phone number for the IRB is (212) 678-4105. Or, I can write to the IRB at Teachers College, Columbia University, 525 W. 120th Street, New York, NY, 10027, Box 151.
- I may request and will receive a copy of the Research Description and this Participant's Rights document.

My signature below indicates I agree to participate in this study.

____ ________________

Participant's name Date

[Please scan and return to Claire Davis at crd2136@tc.columbia.edu.]

Appendix R

Continuing Education Unit Database Data-sharing Agreement

Letter of Agreement

February 15, 2016

Claire Davis
Associate Director, Joan H. Marks Graduate Program in Human Genetics
Sarah Lawrence College
1 Mead Way
Bronxville, NY 10708

Dear Ms. Davis:
This letter shall serve as confirmation of the agreement between yourself and the American Board of Genetic Counseling (ABGC) with regards to data ABGC will provide you in support of your dissertation research regarding adult education.

ABGC will provide you with anonymized entry records for the continuing education activity that Diplomates have entered into the ABGC proprietary recertification software. These records will include the title of the activity, the credit awarded to the activity and how the activity is categorized (Category 1, 2 or PAC).

In return for these records, you will share your research findings with ABGC, acknowledge ABGC's assistance in any publications that arise from this research as well as provide ABGC pre-publication review of any documents regarding this research.

If the terms of this letter meet your approval please sign and return to me at your earliest convenience.

Sincerely,

Sheila J. O'Neal
Executive Director

Approved by,

Claire Davis
Genetic Counselor

Image 5. Data-sharing agreement with American Board of Genetic Counseling (ABGC**).**

Appendix S

Initial Coding Scheme Based on the Literature and Researcher's Prior Experience

I. Responses to scientific discovery
   a. Discomfort (literature; in vivo)
   b. Uncertainty (literature; in vivo)
   c. Reflect on previous training (literature)
   d. Desire additional education (literature; in vivo)
   e. Engage in continued professional learning (literature; in vivo)
   f. Other
      i. Incorporate into existing training programs (literature)
      ii. Experimentation (in vivo)
      iii. Hesitation/reluctance (in vivo)
      iv. Seeking support from colleagues (in vivo)

II. Continued professional learning
   a. As a professional value (literature)
   b. As a form of professional development (literature; in vivo)
   c. Impetus
      i. In response to professional challenges (literature; in vivo)
         1. Scientific innovations (literature; in vivo)
         2. Personally perceived need (in vivo)
      ii. In service to lifelong learning (literature; in vivo)
      iii. To maintain certification/licensure (literature; in vivo)
      iv. Specialization (literature)
      v. Self-direction (literature; in vivo)
   d. Learning strategies
      i. Attending conferences (literature; in vivo)
      ii. Reading professional literature (literature; in vivo)
      iii. Webinars (in vivo)
      iv. Workshops (literature; in vivo)
      v. Process/peer groups (literature; in vivo)
      vi. Other (emerging)
   e. Learning resources
      i. Publications (literature; in vivo)
      ii. Professional societies (literature; in vivo)
      iii. Colleagues (literature; in vivo)
      iv. Educational institutions (literature; in vivo)
      v. Other (emerging)

III. Experiential learning/reflective practice
   a. Approach, as delineated by Schon
      i. Technical rationality (literature)
      ii. Reflection on action (literature)
      iii. Reflection-in-action (literature)

b. Motivation
    i. Proactive (literature; in vivo)
    ii. Concurrent (literature; in vivo)
    iii. Responsive (literature; in vivo)
c. Perception and awareness of reflection (literature; in vivo)
d. Role of others (in vivo)
e. Outcomes
    i. Practices (literature; in vivo)
    ii. Change in perspective (in vivo)
f. Factors supporting or hindering efficacy (literature; in vivo)