SIMULATION-BASED LEARNING IN MEDICAL LABORATORY EDUCATION

CURRENT PERSPECTIVES AND PRACTICES

MOIRA M. GRANT, PhD FCSMLS(D)
KURT H. DAVIS, FCSMLS CAE
CANADIAN SOCIETY FOR MEDICAL LABORATORY SCIENCE
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TABLE OF CONTENTS

EXECUTIVE SUMMARY 1

INTRODUCTION 3

LITERATURE REVIEW 5

DATA GATHERING AND ANALYSIS 21
- Data gathering 21
- Data analysis 23
- Research ethics, confidentiality, and use of data 23
- The researchers 24

FINDINGS AND DISCUSSION 25
- Institutional case studies 25
- Definitional issues 29
- Implementation characteristics of simulated laboratories 31
- What typically happens in a simulation laboratory? 32
- Rationale for use of simulations 35
- Advantages cited for simulation laboratories 36
- Challenges/limitations of simulations 39
- Educational and evidence-based foundations for the use of simulated laboratories 48
- Evaluating the effectiveness of simulated laboratories 49
- The relationship between simulations and clinical placements 56

IMPLICATIONS 59

CONCLUSIONS 63

APPENDICES 65
- A – List of typical topics addressed in interviews 65
- B – Consent forms for interviews (Two versions) 66
- C – List of participants and contributors 69

EXECUTIVE SUMMARY

This report outlines a research project implemented by the Canadian Society for Medical Laboratory Science (CSMLS) and funded by Health Canada. The project was intended to provide the foundations for an evidence base for simulations in medical laboratory education and to identify gaps in evidence in order to inform educational practices, policy- and decision-making processes, and potential directions for further research.

Data gathering included a written survey completed by medical laboratory program directors, site visits, and interviews with instructors, students, graduates, and clinical site personnel. An extensive review of the literature demonstrated the relative lack of published information on simulations in medical laboratory education as well as evidencing the need for further inquiry into the educational validity of simulations in health professional education in general.

The responses of contributors to this study have helped to create a detailed picture of simulation laboratories. Survey respondents and interview participants provided a number of reasons that simulated laboratories are being used in their programs. Challenges with clinical placements were mentioned most frequently as a motivating factor, even in programs that have had their simulation laboratories in place for 25 years or more. Pedagogical validity was rarely cited as contributing to the shift to simulation-based learning and most educators were not aware of any literature that would provide an evidence base for use of these activities in medical laboratory education. Patient safety also does not appear to be a motivating factor in the use of simulations for medical laboratory students.

Study participants who have been involved in simulation-based learning express, for the most part, a great deal of interest and enthusiasm for it. Those who do not have simulations in place are curious about its potential to enhance their program and to resolve challenges with clinical placements.

According to the participants in this study; simulation-based learning activities in medical laboratory programs have positive features that fall into six main categories:

- They enhance the quality of the learning environment.
- They facilitate student acquisition of crucial knowledge, skills, and attitudes.
- They provide opportunities for assessing students.
- They enhance the uniformity of the overall learning experience for all students.
- They have benefits for clinical partners.
- They may facilitate addressing health human resources shortages.

Study participants identified a number of concerns about simulation-based activities in medical laboratory programs. These can be placed in four main categories:

- They are demanding for instructional staff.
- They are resource-intensive.

- Some aspects of laboratory work are difficult or impossible to simulate.
- The quality of the learning experience may be uneven.

The findings of this study suggest the following about simulations in medical laboratory education:

- They can be an effective and supportive tool to enhance student transition into the clinical environment, but can not replace clinical experience;
- They are a major draw on resources (human and otherwise) and must be adequately supported both at startup and on an ongoing basis;
- They represent a significant shift in pedagogical practices and must be grounded in educational resources and research-based evidence which are not currently available to educators;
- They are a rewarding teaching and learning experience when supported with sufficient appropriate resources;
- They offer opportunities for academic and clinical educators to foster a more seamless educational experience;
- There is little evidence to support their use in medical laboratory education;
- Their implementation in medical laboratory education appears to be declining due to a lack of resources, most notably funding, and a lack of evidence base to support their use.
- They must be complemented with effective and well-supported clinical education resources and practices.

Given the great interest in simulations as a means of addressing problems with clinical placements, there is little evidence of their potential to do so, particularly in light of the reverse momentum currently underway in Canadian programs. Despite the attention being given to simulations and the potential health human resources benefits that are being ascribed to them, simulation-based learning is actually in decline in this profession due to lack of ongoing funding. Targeted short-term funding has left medical laboratory programs high and dry when it comes to planning and implementing sustainable simulation-based curricula.

Medical laboratory programs are caught between a rock and a hard place: unable to procure the clinical education they need for their students due to cutbacks in the clinical environment, and unable to implement the curriculum, including simulations, that they see as necessary in their educational institutions due to lack of long-term funding. This stasis is preventing their addressing health human resources issues.

Themes of sustainability and the need for an evidence base for simulations in medical laboratory education have been evident throughout this process of inquiry. They call for increased attention to accountability for health professional education through research and policy making in education and health services.

INTRODUCTION

The past decade has involved a dramatic expansion in the use of simulated experiences in health professional education, particularly in medical education. Educational programs in nursing, dentistry, and counselling professions are also demonstrating increased interest in simulations. Patient safety is often cited as a major reason for this shift. Technological advances have facilitated the growing use of computers and computerized simulators at the same time that health professional programs are encountering increasing challenges to providing their students with authentic clinical experience. Simulation-based learning experiences are often positioned as alternatives to learning at a clinical site or through interactions with real patients/clients.

Medical Laboratory Science (MLS) programs are also adopting or showing interest in simulation-based learning experiences for their students. The goal of decreasing reliance on clinical partners appears to be a major factor in this shift. However, the educational validity of simulated learning does not appear to have been clearly investigated or established in medical laboratory education. There is little current relevant research to guide educators and policy-makers in their considerations of simulations as an educational strategy for medical laboratory programs. Issues of patient safety or improved health care outcomes do not appear to be part of the dialogue about the introduction of simulations into medical laboratory science programs in Canada, nor are there indications of an evidence-based approach or considerations of the educational validity of such practices. As a result, increased use of simulations in MLS education would appear to be driven by economic concerns and workplace constraints in the absence of supporting research to guide it.

This report outlines a research project implemented by the Canadian Society for Medical Laboratory Science (CSMLS) and funded by Health Canada. The project was intended to provide the foundations for an evidence base for simulations in medical laboratory education and to identify any gaps in evidence in order to inform educational practices, policy- and decision-making processes, and potential directions for further research.

In addition to inquiring into and establishing an evidence base for medical laboratory education, the findings of this research project have the potential to inform practices in other professions experiencing similar educational pressures. There is an obvious need for inquiry into this aspect of educational change and to fill the large research gaps that exist in this profession's educational practices. Current practices in simulated medical laboratory education can serve as valuable resources, providing both guidelines for educators and an evidence base for research and policy-making.

At the outset of the project, the following questions were posed to guide the project's research activities:

- How are ‘simulations’ defined, constructed, and implemented in medical laboratory science?
- What are the factors that shape a program’s decision to implement simulations?
- What considerations go into educators’ selection and design of simulated learning experiences?
- What are the resources required to implement, maintain, and evaluate the simulated experience?
- What is the impact of the shift to simulated experiences on other aspects of the learning process?
- How is the effectiveness of the simulation experience evaluated?
- What are the perspectives of those most directly involved in simulated learning in MLS?

The study was carried out in two phases: Phase 1 involved a mailed survey to the coordinators of all general medical laboratory programs in Canada. The survey gathered detailed information on whether institutions conducted simulation laboratories and, if so, how they were implemented. An interim report on the findings of this survey was submitted to Health Canada in March 2007.

Phase 2 of the study consisted of site visits, face-to-face and telephone interviews, tours of educational and clinical laboratory facilities, e-mail queries and networking, and a detailed review of the literature to expand on the information gathered for the project’s initial proposal. The interviews were crucial for creating a fuller picture of the use of simulation laboratories in medical laboratory programs. This report integrates Phase 1 and Phase 2 findings.

One contributor to this project made a pointed and well-taken observation about the title originally proposed for this study, “Simulated learning in medical laboratory education: Current perspectives and practices”. He noted that ‘simulated learning’ is a misnomer since an effective educational activity should facilitate *authentic* learning in a simulated environment. The final title for this report reflects this: “*Simulation-based learning* in medical laboratory education…”[1]

[1] R. Rice, personal communication, April 28, 2007.

LITERATURE REVIEW

This section reviews the literature on simulations in health professional education and has been developed as part of the current CSMLS study, funded by Health Canada, on simulation-based learning in MLS.

Simulation-based Learning: The Literature

The simulations literature for health professions is large and expanding rapidly. Searches of the medical and education literature for ‘simulation’ or ‘simulated’ return thousands of publications, although the majority of these deal with teaching specific skills in medical and nursing education. This body of literature has evidenced exponential growth within the last ten years (Eder-Van Hook, 2005).Much of it focuses on evaluation of specific, small-scale techniques in the medical or nursing professions and is beyond the scope of this review.

Simulation-based learning has been defined as the “reproduction of some aspect of reality …[to] better understand, manipulate or predict real behaviour”(Kneebone & Nestel, 2005, p. 86). Other terms associated with simulations have included ‘surrogate’ or ‘recreation’ of reality, an activity that mimics reality, a controlled environment, immersive or guided experiences, fully interactive tasks, activities comprised of techniques rather than technology, and a replacement or amplification of real experiences with guided experiences that are often immersive in nature (Gaba, 2007; Sinz, 2007).

As presented in the literature, simulations in health professional education take the forms of role play, videotaped interactions, case studies, demonstrations, computer-based learning modules, online activities, standardized patients, virtual reality applications, and mannequins or plastic body parts. A recent survey reported that the most common type of simulation used by health professional educators is full mannequin patient simulation (used by 80% of the survey participants); almost 80% of participants use task-specific trainers; 62% utilize standardized patients (actors); 60% make use of case reports/problem based learning; 57% employ virtual environments; and 57% use flat screen computers (Sinz, 2007).

Simulations are often discussed in terms of ‘low fidelity’ vs. ‘high fidelity’, a distinction that appears to be closely linked to the level of technological sophistication they demonstrate (Maran & Glavin, 2003). High fidelity refers to sophisticated computerized simulation of whole patients (‘patient simulators’) or various anatomical parts (Good, 2003). A number of authors have reported the growing use of ‘skills laboratories’ as sites for skills acquisition for health professionals (for example, Wellard, Woolf & Gleeson, 2007).

Simulations have been advocated for preparing practitioners for anticipated events (Gaba, 2004); for continuing education and recredentialing (Becker, 2005); and for undergraduate education, with which it is commonly associated. Increasingly, simulation-based learning is seen as an ideal way to prepare students for the clinical environment and as a means of evaluating clinical deficiencies (Issenberg, McGaghie, Petrusa, Lee Gordon, & Scalese, 2005; Kneebone & Nestel, 2005). More than 90% of respondents to a recent survey among educators reported that they used simulations for testing, evaluating and credentialing; 86% use them for teaching; 60% for research; and 29% for product safety assessment (Sinz, 2007).

As the literature has evolved from descriptions or evaluations of individual simulation strategies to a more critical examination of simulation practices, authors have increasingly sought to create typologies for simulation activities. Huang, Gordon, & Schwarzstein (2007) categorize simulations along the following lines:

- concept simulation using computer-based animation;
- virtual patient simulation to reproduce clinical scenarios;
- part-task training for procedural or psychomotor skills;
- high-fidelity patient simulation using computerized mannequins.

Gaba (2007) outlines 11 dimensions for describing simulations; these take into consideration the purposes of the tasks, the characteristics of the participants, the physical environment, the skills being taught, and the nature of the learning activities, among other characteristics. Loyd, Lake and Greenberg (2004) have described the resources, types, applications, and evaluation of simulations in their discussions of developing and operating a simulation center and assessment simulations that reflect specific educational curricula.

A number of authors have outlined features they consider to be essential for the implementation of effective simulations. These include relevance to practice, foundations in educational theory, curricular flexibility and integration, resource support, and appropriate staff development (Bradley & Postlethwaite, 2003; Issenberg et al., 1999; Kneebone, Scott, Carzi, & Horrocks, 2004; McLaughlin, Doezema, & Sklar, 2002; Oermann, 2004). Issenberg et al. (2005) have outlined what they consider to be the ten essential features of simulation-based learning: feedback (considered by these authors to be the single most important feature for effective learning); repetitive practice; curriculum integration; range of difficulty levels; multiple learning strategies, representation of clinical variation; individualized learning; defined outcomes or benchmarks; and simulator validity. Salas and Burke (2002) maintain that simulations must be carefully crafted to include instructional features, guided experiences, performance measurement, diagnostic feedback, and a relevant match to the environment being simulated. According to Kneebone, (2006), the desirable attributes of simulations are: (a) repeated practice in a safe environment; (b) expert guidance when needed; (c) relevance to actual clinical practice; (d) learning with others in a realistic context; (e) a supportive, learner-centred milieu.

The extent to which a learning environment must mimic reality is the topic of ongoing debate in the literature. How closely a simulation imitates reality (its ‘fidelity’) is an important consideration (Alessi & Trollip, 2000). As Gaba (2006) sees it, the type of simulation used and the level of realism needed must be based on the type of thinking processes to be fostered (for example, procedural, psychomotor, or decision-making). He notes a need to determine whether realism enhances the learning experience. Others point out that simulation must offer opportunity to gain transferable skills/knowledge. Christensen, Heffernan and Barach (2001) suggest that large scale simulation is not always necessary. Similarly, Huang et al. (2007) maintain that high-tech fidelity is not always needed, nor is it appropriate, for learning activities to be effective.

Recent literature evidences increasing attention to feedback and reflective processes in simulations (Issenberg et al., 2005). In their detailed discussion of the merits and elements of reflection in simulations, Fanning and Gaba (2007) maintain that reflection is the heart and soul of the experiential learning facilitated through simulation-based learning. They contend that it provides students with an opportunity to make sense of what they have experienced but note that debriefing of an educational experience requires a supportive climate. Savoldelli et al. (2006) point out that mere exposure to a simulation is not effective and that students need to have constructive feedback. Others propose using debriefing and post-debriefing scenarios as a means to assess learning (Podraza et al., 2007). Dismukes, Gaba and Howard (2006) assert that facilitated debriefing of a simulated activity fosters metacognitive skills in students, but they, too, caution that this strategy requires training for educators.

Support for Simulated Learning Experiences

In their discussions of medical simulations, Huang et al. (2007) see the opportunity for assessment as the major advantage for medical simulation: they note in particular the potential for capturing behaviors in contexts similar to actual practice. They see distinct advantages in the fact that the setting is reproducible and that simulation allows measurement of skills such as communication and professionalism, which are otherwise difficult to evaluate. They also suggest the following positive features for simulations:

- fostering team-based approaches and opportunities for longitudinal monitoring;
- providing a platform for standardized education and assessment of learners;
- promoting uniformity of curricula;
- helping to develop critical thinking;
- promoting patient safety;
- ensuring exposure to both rare and common events;
- promoting task repetition for performance improvement;
- potentially accelerating acquisition of expertise over time;
- allowing assessment of psychomotor and interpersonal skills;
- providing opportunity for structured reflection through debriefing.

There is a great deal of support for simulation-based learning elsewhere in the literature, as indicated by the many positive features cited for simulations, including:

- facilitating ongoing integration of theory and practice (Fanning & Gaba, 2007) especially when it involves planning and implementing procedures/activities (Bello, Kneebone, Tierney, Nestel, & Darzi, 2007) or when sufficient clinical placements are not available (Shepherd, Kelly, Skene, & White, 2007);

- reducing participant anxiety and increasing self-confidence (Hillard & Andreatta, 2007; Pliego & Rajab, 2007);
- enhancing faculty knowledge and skills (Alinier, 2007);
- introducing curriculum items not possible through traditional teaching strategies (Carney, Marra, Buttery, & Baxendale, 2007);
- helping to maximize the learning opportunity of the clinical placement (Maran & Glavin, 2003);
- providing opportunities for disaster and adverse-event planning (Smith, 2004);
- reduced health care costs, fewer adverse events, fewer malpractice claims and lower malpractice insurance rates (Eder-Van Hook, 2005; Washington State University, 2007);
- creating opportunities for learning professional language and participating in interprofessional and teamwork-based activities (Dillon, Noble, & Kaplan, 2007; Podraza et al., 2007);
- provision of feedback; opportunities to improve technical, motor, communication, diagnostic and decision-making skills; enhanced acquisition and retention of knowledge; opportunities for repetitive practice and to make/detect/correct errors without adverse consequences, intervention, or risk to patients; creation of complex, high-stress, high-performance environments typical of health care sites; provision of a controlled, standardized environment; adaptability to multiple learning strategies and replication of differing clinical conditions; hands-on experience with authentic equipment, or uncommon situations or procedures (Botella, Perpiña, Baños, & Garcia-Pacios, 1998; Good, 2003; Gordon, Brown, & Armstrong, 2006; Gordon, Oriol, & Cooper, 2004; Issenberg et al., 2005; Issenberg et al., 1999; McLaughlin et al., 2002; Mondello & Montanini, 2002; Satish & Streufert, 2002; Shepherd, Kelly, Skene, & White, 2007; Shukla et al., 2007; Small et al., 1999; Triola et al., 2006).

Simulation provides options to the sometimes ‘hit and miss’ aspects of clinical education in the real environment (Henderson, 1998) and offers increased efficiency in that limitations of time that are involved with live patients do not apply (Reznek, Harter, & Krummel, 2002). Numerous studies on the validity and outcomes of simulated learning have reported satisfactory findings, i.e., that simulations are at least as valid and effective as traditional methods for teaching, learning, and assessment (for example, Grantcharov et al., 2004). In general, the literature seems to suggest student satisfaction with the authenticity and outcomes of simulated experiences (McLaughlin et al., 2002; Mondello & Montanini, 2002; Treadwell & Grobler, 2001). Researchers have reported increased short term knowledge and greater learner satisfaction with simulations as compared to textbook-based learning activities (Reynolds, Bastos, Ayres-de-Campos, & van Meurs, 2006)

The Critique of Simulations

Simulations in health professional education have been criticized from a number of perspectives, including their use of costly resources and the lack of a research foundation to validate their use (Becker, 2005; Bradley, 2006; Gaba, 2004; Huang et al., 2007; Issenberg et al., 2005; Mondello & Montanini, 2002). Much of the literature is ambiguous or insufficiently rigorous to support the use of simulation (Issenberg et al., 2005). While there are hundreds of studies examining the content and construct validities of simulations or comparing students’ performances in simulations and traditional settings, transferability of the findings is challenging because of the limited scope of the techniques studied. Outside of medicine, dentistry, and more recently, nursing and counselling, implementation of and research into simulations appears to be quite limited.

Gaba (2006) cautions that ‘as if’ situations may encourage cavalier behaviour, hypervigilant behaviour, gaming the system, or focusing on the imperfections or faults in the simulation rather than on the learning. There is also the danger of fragmentation of tasks, losing the big picture, or overfocusing on crises and unusual situations (Kneebone, 2006). Participants may find simulated environments intimidating and stressful and they may fear judgment by their instructors and peers (Savoldelli, Naik, Hamstra, & Morgan, 2005). Not all students can learn effectively through simulations (Nimmo, 2006) as such environments require students to suspend their disbelief. Educators must be aware of the demands that ‘as if’ situations place on students (Dieckmann, 2006) and consider the various models of engagement that may characterize simulation-based learning (Rudolph, Simon, & Raemer, 2007).

Faculty may be resistant to new teaching strategies required for simulations (Huang et al., 2007) and must be supported in such transitions. Issenberg (2006) has pointed out that the need for skilled educators has taken a back seat to training resources (for example, instrumentation); he notes that educators serve as information providers, role models, facilitators assessors, planners and resource developers, and must be appropriately supported in these roles. Institutions using simulations need to provide appropriate supports and resources for faculty: this requires a change to values in the curriculum, and not just materials or technological resources, in order to get buy-in from faculty (Baxendale & Buttery, 2006). Kneebone (2006) notes that many models privilege technology over the human resources required for simulations, even though realism isn’t necessarily a function of technology. This suggests that the supports provided to educators must be as much a consideration for the success of a simulation as the presence of sophisticated technology.

Simulations create high demands for infrastructure support (Huang et al., 2007). Because of the high cost of simulations in terms of both implementation and sustainability, educational programs must seek to reduce the cost of consumables and ensure that the simulations are linked to a ‘robust course portfolio’ to optimize use of the simulation facilities (Pease, 2006). The economic viability of simulations depends on high use of facilities and on external funding. In theory, they offer opportunities to reduce health care costs by improving patient care and by reducing training time in clinical sites, but this has not been validated (McIntosh, Macario, Flanagan, & Gaba, 2006). Programs that wish to implement simulations need institutionalized forms of support, for example, funding, common metrics and standards, partnerships, greater public awareness, advocacy, and validation studies and other forms of research (Gaba & Raemer, 2007).

Issenberg and Scalese (2007) have commented on the lack of an evidence-based approach to simulations in health professional education. Researchers have noted the need for validated studies at higher levels of learning, and the need to look into competency assessment (Reznick &

MacRae, 2006). Glavin (2007) has observed that simulations are sometimes implemented before important issues, such as how to assess student learning, are established. He points to Kirkpatrick's (1996) hierarchy on levels of learning in training and suggests that planning is necessary to ensure that simulations address higher-level skills. Other authors note problems with a lack of standards for using simulations for assessment (Barach, Satish, & Streufert, 2001).

With the exception of a few meta-analyses (for example, Issenberg et al., 2005) there has been little examination of educational programs' adoption or implementation of simulations in general, and only a few inquiries have applied a critical perspective. Some researchers continue to maintain that there is no substitute for authentic experience in a clinical environment (du Boulay & Medway, 1999; Gonczi, 2001; Kneebone et al., 2005; Whitcomb, 2005, among others). Theories of situated learning (Lave & Wenger, 1991) argue for a substantial apprenticeship-like practicum in health professional education and its opportunities for construction of a professional identity within a community of experienced practitioners. These points support the view that simulation should not operate in isolation from the clinical context, but should operate alongside it through integration of simulations with clinical experience (Scott, Darzi, & Horrocks, 2004). However, there is no research that has inquired into the implications of these latter perspectives for simulated learning in medical laboratory education or, indeed, in the health professions in general.

The Driving Forces Behind Use of Simulations

Patient safety and related ethical issues are frequently cited as major reasons for implementation of simulations for teaching health professionals (Committee on Quality of Health Care in America, 2000; Smith, 2006; Vozinilek, Huff, Reznek, & Gordon, 2004). Consistent with these concerns is the observation that the more complicated and/or invasive the procedure, the more likely it is that simulation will be seen as worthwhile (Greene, Zurakowski, Puder, & Thompson, 2006).

Simulations have been linked to various interests of stakeholders in health care. Educational programs see in simulations an opportunity for improved learning and a competitive edge over other programs or a means of coping with declining clinical education opportunities for their students. Professional and licensing associations push for improved practitioner performance, maintenance of competence in response to public pressure and government regulation. Health care organizations aim to improve patient care and efficiency, reduce costs, and position themselves well in the health care market. Reduced costs are also sought by funders of medical care, in addition to reduced errors. Liability insurers want to reduce claims and the related payouts. Governments respond to public pressures to reduce costs, and minimize errors. The public advocates for improved patient care and safety, reduced 'training' on patients, and uniform competence and proficiency of health professionals. Gassert (2006) has recently made a connection between the use of simulated learning experiences and addressing health human resources issues in the U.S. nursing profession, so simulated learning may be constructed in some contexts as a means to address professional shortages.

Educational Foundations for Simulation-based Learning

Wellard, Woolf and Gleeson (2007) see the recent approaches taken to learning through simulations as based on tradition and fiscal challenges, rather than on much-needed pedagogical principles. Indeed, it is only within recent years that the simulations literature has demonstrated a shift to considerations of the foundations for simulation-based learning in educational theory. Table 1 notes the bodies of literature that have been cited as relevant to simulation-based learning.

EDUCATIONAL THEORY	RELEVANT REFERENCES
Situated learning	Altalib (2002); Lave and Wenger (1991)
Workplace learning	Eraut (2000; 2001); Browne (2007)
Experiential learning	Kolb (1984); Gibbs (1988)
Social learning theory	Bandura (1977)
Adult learning theory	Knowles (1988); Seaman and Fellenz (1989); Huang et al. (2007)
Reflective practice	Schön (1983; 1987)
Hierarchies of training	Kirkpatrick (1996)
Acquisition of expertise	Ericsson (1996)
Zone of proximal development; cognitive apprenticeship; culturally-mediated learning	Vygotsky (1978)
Social construction of learning; team learning	Bleakley (2006)
Complexity theory	Kneebone (2006)

Table 1: Educational theories, with relevant references, cited in the literature as pertaining to simulation-based learning

Educational validity seems almost to have been an afterthought in the adoption of simulation-based learning, as though it has been led by technology or necessity, rather than by a foundation in evidence. Kneebone (2006) has recently advocated the development of a 'theory of simulations' and the literature shows some promise for development in this direction. Alessi and Trollip's theories of learning (2000) are based on attributes of the body of knowledge, of the learner, and of the simulation environment, but arise from the computer-based learning environment; their transferability to a simulation environment has not yet been established. Jones and Alinier (2006) have proposed a six-dimension framework for student learning. Indeed, it would appear that the literature is becoming richer in theories of and approaches to teaching and learning that are specific to simulation-based environments. Dieckman (2006) has explored the modes of validity, reality, and fidelity that go into a simulation-based learning activity while Feinstein and Cannon (2002) have outlined a systematic approach to designing assessment of learning through simulations. McGaghie (2006) has adopted a future-oriented approach in his elucidation of agendas for both simulation-based learning and research on simulations. Huang et al. (2007), among others, have stressed the need for research and defined outcome measures, especially given the high costs of simulations.

Simulations in Medical Laboratory Science Education

Although there is much discussion of the use of simulations in medical laboratory science, there is little substantial and recent published research. A 1983 study reported on the use of a training course under simulated 'stat lab' conditions (Green & Hiss, 1983). The author of a 1984 doctoral thesis noted that the introduction of written simulations into a medical laboratory program produced no discernable difference in students' professionalism as measured by error rates in performance of diagnostic tests (Anderson, 1984). Fraser (1986) described computer based case study simulations for medical laboratory students. The authors of a 1989 study reported satisfactory performance of medical laboratory technicians trained using only simulation as compared to programs where students trained in affiliate hospitals (Bauer & Newman, 1989). Baines (1990) found significantly higher scores on national certification examinations among medical laboratory students trained with simulated laboratory experiences as compared with those trained in medical laboratory settings. However, this difference was confined to just one procedure in one of the sub-disciplinary areas studied by MLS students, clinical chemistry. Rice (1994a; 1994b) has described the use of computer simulations for initial and continuing education, particularly in hematology.

Computer simulations have been suggested as a possible means of remedying deficiencies in troubleshooting skills observed in new graduates of medical laboratory programs (Rudman, Lunz, & Summers, 1995) and for assessing competency among practitioners (Schwabbauer, 2000). Simulated laboratory experiences have been described as a valuable tool for permitting students to becoming familiar with the clinical environment and for assessment of student performance (1998). Chiasera and Rudman (2003) found no difference in student performance on tests following use of computer modules for a single analytical procedure and suggested simulated learning as a means to decrease teaching costs and increase access to laboratories.

This relative paucity of supporting research notwithstanding, there is a growing interest in use of simulated laboratories among medical laboratory programs in the U.S. due to difficulties in finding and retaining clinical sites that will train their students (Cearlock, Isabel, Etnure-Zacher, & Miller, 1999; Ward-Cook, Simpson, & Brito, 2000). Introduction of simulations into medical laboratory programs has been proposed as one possible means of 'saving' programs in the U.S. that are in danger of closure due to financial constraints (Poeggel, 2006).

Similarly, a 2004 study by the CSMLS on clinical education for Canadian medical laboratory technologists reported the growing construction of clinical education as a 'burden' that must be shifted from clinical sites. The study noted that simulated learning was one of the strategies reportedly being employed or considered by educational programs to circumvent declining participation by clinical partners in educational processes (Grant & Davis, 2004). The study also pointed to potentially problematic variations in definitions of simulations that confounded comparisons among programs. In addition, there are educators who consider the traditional student laboratory activities, which have been in use for decades, to constitute simulated laboratory activities. Their observations suggest that the supposedly recent trend toward simulated laboratory learning in medical laboratory education may, in fact, be a re-definition of an established practice. These definitional variations merit clarification through further research.

The evolving role of simulation-based learning in medical laboratory education can be seen in its use in Canadian medical laboratory programs: two programs have had simulation laboratories in place for decades; significantly, these two programs also report the shortest student clinical placement periods (10 and 12 weeks, as compared to the 26 to 42 weeks reported by other programs), although one of the programs anticipates decreased use of simulations. An Alberta study proposed setting up a simulated clinical laboratory environment as a means of expanding the province's capacity to provide more medical laboratory technologists for the workplace while lowering the field costs for clinical education (Rasok, Hughes, & Tron, 2004). This has resulted in simulation-based learning initiatives in that province that are experiencing challenges with obtaining funding. At least one other Canadian program has recently announced its intentions to make simulation laboratories an explicit aspect of its educational curricula.

Educators, practitioners, and students have expressed scepticism about the appropriateness of simulation for medical laboratory education (Grant & Davis, 2004), echoing concerns voiced by laboratory managers in a U.S. study (Lemery, 2001). In the former publication, instructors in clinical sites mentioned three areas of apprehension regarding simulations: the transferability of technical skills gained through simulations to the workplace; the relevance of skills gained in a simulation at the educational institution (as many institutions were noted to use out-of-date equipment); and the loss of opportunities for professional socialization to occur within the authentic environment or for employers and students for mutual 'sizing up' prior to employment.

Medical laboratory students have reported being aware of the artificial nature of simulated laboratory activities and have adjusted their engagement in and valuing of the experience (Grant & Davis, 2004). Students commented that their most memorable learning opportunities in clinical education arose as a result of:

- working side by side with MLTs who model profession-specific behaviour and problem solving;
- feeling like a member of a team in a collegial health care environment;
- gaining a sense of contributing to patient well-being;
- appreciating the rhythm and challenges of real-life laboratory workflow and the strategies for addressing them;
- experiencing non-routine aspects of laboratory procedure and patient specimens; and
- working with up-to-date techniques and instrumentation.

It is not readily apparent how effectively simulated laboratory activities address these types of learning opportunities, and this constitutes one aspect of the major research and evidence gap on simulations in medical laboratory education.

Discussion

There appears to be little published evidence about the use and effectiveness of simulation-based experiences for medical laboratory education, and there are instances where the models of simulations described in the literature are not applicable to the medical laboratory environment.

For example, much of the literature focuses on high-fidelity patient simulation or assumes that invasiveness and direct patient contact are part of the scenario that needs to be simulated; however, patient contact is not a major aspect of medical laboratory work. With the exception of a paper on phlebotomy (Scerbo, Bliss, Schmidt, & Thompson, 2006), few of the simulated activities described in the literature are directly applicable to medical laboratory education. Many of the models described in the literature assume the presence of a medical school, which is not the case for the majority of medical laboratory programs. One source refers to the 'risk free environment' of simulations (Washington State University, 2007); this is not true for medical laboratory simulations, as students work with biohazardous materials that constitute a safety risk for them and their instructors. The term 'clinical laboratory' is used in the literature to refer to the physical learning environment within which medical and nursing students carry out their simulation-based activities, but there is nothing in the literature that refers to simulation exercises that re-create an authentic clinical diagnostic laboratory.

Issues of patient safety or improved health care outcomes do not appear to be part of the dialogue about the introduction of simulations into medical laboratory science programs in Canada, nor are there explicit indications of an evidence-based approach or considerations of the educational validity of such practices. As a result, increased use of simulations in MLS education would appear to be driven by economic concerns and workplace constraints in the absence of supporting research to guide it. As well, accreditation of educational programs, standardization of graduate competence, and national portability of credentials must be considered when individual educational programs make major changes to their curricula.

There are no models in the literature for simulations that are relevant to medical laboratory educators, nor is there any evidence to support their use. There is an obvious need to inquire further into this aspect of educational change and to fill the large research gaps that exist in this profession's educational practices. Medical laboratory educators can learn from practices in other medical laboratory programs and in other professions. Certainly, they will benefit from the increasing attention to educational theory in publications about simulations. In the absence of relevant literature, current practices in simulation-based medical laboratory education can serve as valuable resources, providing both guidelines for educators and an evidence base for research and policy-making. There is a need to develop models, resources, and an evidence base for use of simulations in medical laboratory education. This makes a strong and urgent case for further inquiry.

Conclusion

There is no denying that simulations in medical laboratory education are drawing a great deal of attention and that they have the potential to contribute to the preparation of new practitioners. Much has been written for other health professions and about specialized techniques, but there is very little that is relevant to medical laboratory education. However, there is a definite need for an evidence base for simulation-based learning in medical laboratory science programs in Canada in order to provide educators with exemplars of simulated laboratory learning, to give weight to their efforts to change curricula, and to identify directions for further research and educational change. The construction of this evidence base is essential for decision- and policy-making about future directions for medical laboratory education.

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DATA GATHERING AND ANALYSIS

Data gathering

This study has built on prior research[2] to inquire into the use of simulated laboratory experiences, both actual and anticipated, in Canadian medical laboratory programs. An extensive literature review was conducted to inform and ground the study, as well as to serve as a resource for educators and other researchers. Because initial examination of the literature suggests that there is limited published data on simulations in medical laboratory education, medical laboratory educators and current practices in simulation-based learning were considered to be valuable resources for this study. Data collection consisted of telephone/e-mail contacts and written surveys, which took place in Phase 1 of the study; and site visits/face-to-face and telephone interviews, which were conducted in Phase 2.

Phase 1

In February and March of 2007, twenty-five coordinators of Canadian general medical laboratory and bridging programs were contacted by e-mail to ascertain whether they use simulated laboratories as part of their curriculum. Telephone and e-mail messages followed up with non-responders to the initial queries. Programs were divided into two categories on the basis of their responses to the initial e-mailing: those that conduct simulated learning activities and those that do not. (It was felt that this would be the most efficient use of the participants' time). Both groups were targeted, in English or French as appropriate, with surveys addressing the specific needs and experiences of the two categories.

The survey of the group that reported using little or no simulation asked about the types of activities that are simulated or whether the program has plans to implement large-scale simulation-based learning in the future. For those programs that report large-scale use, the survey posed questions about implementation of and challenges to simulations, including specific queries about costs, motivating factors, implementation strategies, evaluation measures, and the evidence-based decision-making that underpinned their program's adoption, design, and applications of simulations. Both groups were asked if they could share literature or other resources on simulation-based learning in medical laboratory science.

Surveys were followed up with respondents by telephone, where necessary, to ensure completeness of the data. One program director requested a telephone interview rather than a written survey. Further details are outlined in the Phase 1 report, submitted previously.

Phase 2

Programs whose survey responses indicated that they use simulation-based learning experiences to a significant degree were contacted to determine the feasibility of site visits and interviews with instructors, students, program graduates, and clinical site personnel. In addition, the principal investigator contacted the program coordinator at one institution undertaking extensive curriculum and infrastructure re-design in order to incorporate simulations into its health

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[2] Grant, M. M. & Davis, K. H. (2004). Clinical placements for Canadian medical laboratory technologists: Costs, benefits and alternatives. Hamilton: Canadian Society for Medical Laboratory Science.

sciences programs; although its simulation facilities are not yet in place, the staff's experiences with planning and implementation were thought to be relevant to this study. The principal investigator visited six educational institutions, toured the simulated laboratory facilities of five of these, visited 3 clinical sites and spoke with a total of 99 individuals at 9 sites:

- The Michener Institute for Applied Health Sciences, Toronto ON (full-time medical laboratory program and the Access and Options bridging program for internationally-educated medical laboratory professionals).
- Mohawk-McMaster Institute for Applied Health Sciences
- University of Alberta and the University of Alberta Hospital, Edmonton AB
- Northern Alberta Institute of Technology, Edmonton AB (Accelerated and full-time Medical Laboratory Technology programs).
- College of the North Atlantic and its clinical partner, the Health Sciences Centre, St. John's, NL.
- New Brunswick Community College and its clinical partner, Saint John Regional Hospital, Saint John NB.

The six institutions are described in the case studies provided in the 'Findings and Discussion' section. Program coordinators were given an opportunity to review the case studies for accuracy and completeness.

Table 2 presents the distribution of interview participants for both face-to-face and telephone interviews.

Participant category *	**Number**
Simulation instructors	24
Academic instructors	4
Academic administrators	7
Clinical educators	24
Laboratory administrators	9
Students	27
Recent graduates	4

Table 2: Numbers of interviews by participant categories conducted for Phase 2 of this study.

* Note: Job titles vary widely from one institution to another. For the purposes of this report, a 'simulation instructor' is an individual who plans, prepares and implements student simulation laboratories; an 'academic instructor' is one who may be involved in the students' lectures and classes but is not directly involved in the simulation laboratories; 'clinical educators' include all those who take part in the learning process of students only in the clinical environment, and this term encompasses 'clinical instructors', 'mentors', 'preceptors', 'teaching techs', and other technologists with whom students come in contact.

Program coordinators at the selected sites were very helpful in setting up interview schedules with instructors, students, and clinical personnel. As well, they facilitated tours of the teaching and laboratory facilities at their educational institutions and affiliated hospital sites. The two- or three-day on-site visits to the simulation laboratory facilities and clinical sites of education institutions permitted observation of the physical implementation of a simulated laboratory (the ‘definition-in-action’) as a means of clarifying and elaborating on the Phase 1 survey responses. These visits included interviews with those most closely involved with simulated learning experiences: instructors at the educational institutions and clinical sites, students and former students, and laboratory directors.

Face-to-face interviews lasted 45 to 60 minutes and followed a semi-structured format (see Appendix A for an outline of the topics that were addressed). Participants were interviewed individually or in small groups, as their schedules permitted. Participants signed a consent form before the interview began. (The consent form supplied to interviewees was modified after the first two site visits in order to make it easier to provide them with a copy. The two types of consent forms used in the study are provided in Appendix B). Where ambient noise levels permitted, interviews were audio-taped. Because large parts of interviews took place during walking tours of facilities, and because clinical laboratories are fairly noisy environments, not all interviews were amenable to audiotaping. The principal investigator also took detailed field notes during the interviews and tours. Telephone interviews were not audiotaped, but extensive notes were taken. Thematic analysis of interview comments was conducted manually.

Several participants recommended others outside the original interview schedules. Most of these ‘snowball’ interviews took place by telephone. Three further individuals were asked to participate in telephone interviews but were unable due to their work schedules. One former educator sent in unsolicited insights and comments that proved useful for this study. In all, 99 individuals were interviewed for the study’s Phase 2, 93 of whom participated in face-to-face interviews. A total of 112 individuals contributed to this study through surveys, interviews and other correspondence. A list of study participants is included in Appendix C.

Data analysis

The principal investigator translated survey responses submitted by francophone programs. Non-narrative survey data were recorded using survey analysis software (SPSS). Thematic data analysis was undertaken to identify major aspects of the simulation-based learning activities in the programs studied. A quantitative representation of these themes was also entered into SPSS. The thematic analysis involved a search for patterns and regularities in the data, as well as contradictions and tensions between the various views of the participants and recorded observations.[3] Some of these patterns began to emerge in the earliest interviews and were confirmed in an iterative fashion with subsequent interview participants.

Research ethics, confidentiality, and use of data

Prior to implementation of the research study, the proposal was reviewed and approved by an *ad hoc* ethics review committee appointed by the CSMLS.

[3] Kvale, S. (1996). *InterViews: An introduction to qualitative research interviewing.* Thousand Oaks CA: Sage.

Although educational institutions are referred to in this report as “Institution A”, etc. and the names of interview participants are not used with their comments, it is difficult to mask all identifying characteristics of each program, particularly since the use of simulation is limited to known institutions in Canadian programs. As a result, it has not been possible to guarantee anonymity to participating programs or participants.

The principal investigator and consultants will not reveal identifying information that is not essential to the understanding of the study at any stage of the project or thereafter, unless permission has been given by the individuals involved. This confidentiality extends to follow-up communication with interviewees and other stakeholders in the review process as well as to any publications that result from the project. These terms of confidentiality were explained to participants verbally or in a consent form, a signed copy of which has been retained by the CSMLS. In the case of written surveys, submission of the survey by the participant was considered to be consent to use of the response data. The consent of some interviewees was gained implicitly by virtue of their participation in telephone interviews; these were not recorded.

Written and audio-taped survey and interview materials related to this project will be kept in a secure storage unit for a period of five years, after which time they will be destroyed.

The CSMLS retains the rights to raw data, to publications arising from the findings, and to use of the data and conclusions for further study, policy making, and research.

The researchers

Dr. Moira Grant, PhD FCSMLS(D), CSMLS Director of Research, has served as Principal Investigator for this project. Dr. Grant is a medical laboratory technologist and educator who has worked with the CSMLS on prior research projects and issues of interest to the medical laboratory profession. Kurt H. Davis, FCSMLS CAE, CSMLS Executive Director, has consulted on this project as well. The CSMLS administrative staff facilitated mailings and report preparation.

FINDINGS AND DISCUSSION

The findings of the Phase 2 interviews validated and expanded upon those reported for Phase 1. The following discussion represents an integration of the findings of both phases. For more detailed information on Phase 1 findings specifically, please refer to the Phase 1 report, published separately.

The comments of survey and interview participants appear in ***boldface italicized*** text.

Institutional case studies

The six educational institutions that participated in site visits are described below.

Case A

Institution A has been conducting simulated student laboratories for almost 40 years. At the end of the program's second year, students participate in seven weeks of simulated laboratories at the educational institution in all five laboratory disciplines (7 days per discipline, 6 hours per day, one discipline after another – a typical 'block' format) followed by a three-week clinical practicum. A further 15 week simulation semester takes place at the start of Year 3 (15 days per discipline, also in a block format). This is followed by a 15 week clinical placement at affiliated hospital laboratory sites.

The institution has five dedicated student laboratories, one for each of the laboratory disciplines, as well as ancillary spaces for processing, storage, and instructor use. Laboratories vary in size and were constructed within the last 10 years; they are spacious (up to 30' x 45') and some have large windows; all can accommodate 14 students and meet BSL-2[4] standards. The instructor:student ratio in the simulation laboratories varies from 1:10 to 1:14, depending on the class size. Most routine laboratory procedures are simulated and very basic technology is employed.

Case B

Institution B has offered simulated laboratories since the 1970s. The instructor:student ratio is 1:10. Simulated labs in all five laboratory disciplines constitute 60% of the college-based program. Labs begin second term, and run daily, with a lecture at the start of the day. They are scheduled in a block format (one discipline after another). The laboratory spaces vary in size from about 20'x 30' to 30' x30' and meet BSL-2 standards; some laboratories have windows; they accommodate 12 to 18 students, some with accessory rooms. There is one dedicated

[4] Biosafety Level 2 (BSL-2) criteria outline requirements for personnel training, personnel access, containment devices, biosafety equipment, administrative controls, and practices and procedures to maximize safe conditions for laboratorians working with agents of moderate risk to personnel and the environment. (http://www.phac-aspc.gc.ca/publicat/lbg-ldmbl-04/index.html) Medical laboratory students handle human tissue and body fluid specimens that are considered to be biohazards necessitating BSL-2 precautions.

laboratory for each of the five laboratory disciplines, as well as a chemistry ‘automation’ room and a general prep room.
Instructors at Institution B expressed doubts that the laboratory sessions they call ‘simulated’ would resemble other programs’ implementation of simulated laboratories, and suggested instead that they may be extended versions of traditional student laboratories (2- or 3-hour laboratory sessions focused on one or two techniques). This program has plans to increase its clinical placements from the current 12 weeks to 22 or 24 weeks and to eliminate its simulated laboratories. These changes are part of an institution-wide shift to a common core curriculum for its health sciences students and will be accompanied by an increase in the medical laboratory program length by one semester.

College personnel cite cost as the main factor in decreasing the use of simulation laboratories, in particular the costs of purchasing up to date instruments and related expendables, and the costs of maintaining the current instrumentation: the institution is unable to sustain the simulated laboratories in their current form. Once the extended clinical placement periods are in place, the college will adopt a more traditional academic format for its laboratories and focus on demonstrations, manual techniques and basic automation. Instructors see these changes as an opportunity to integrate lectures and labs and to facilitate more reflection on the learning experiences. It is felt that the needs of the program are best met by increasing time in the clinical environment.

Case C

In 2006, Institution C offered a 10 month long Medical Laboratory Technology Accelerated program for internationally educated Medical Laboratory Technologists and Canadian trained Medical Laboratory Technologists wishing to re-enter the workforce after an extended absence. This program included a five-month May-to-September simulated laboratory experience (669 hours) with sequential ‘blocks’ of laboratories for each of the five laboratory disciplines and a two-week simulated ‘core’ laboratory. Urinalysis and phlebotomy learning experiences were dispersed throughout the 22 week period. There was no clinical placement experience associated with this program, but students visited laboratories as part of a hospital tour and participated in job shadowing activities.

The program used student laboratory facilities already in place for the institution’s full-time Diagnostic Laboratory Programs. Typical rooms are 20’ x 30’ and BSL-2 compliant. The simulated laboratories were scheduled in the summer months when the laboratories could be dedicated to the program, as well as during the day during the months of May and September when the full time programs were also utilizing the laboratories. The instructor:student ratio was 1:7. This program was funded on a pilot basis by Human Resources and Skills Development Canada (HRSDC) and received initial funding from the provincial ministry of Advanced Education for purchase of equipment and development of the program. However, further funding from HRSDC or the Advanced Education ministry for the program’s second year was not forthcoming as it was considered to be too costly. Therefore the program did not proceed beyond its initial pilot year. According to the program coordinator, the costs of the program could have been cut dramatically if the simulated laboratories were removed from the curriculum; however, it was felt that the laboratories were a particularly vital part of the learning experience for internationally educated individuals, particularly since the institution was unable to procure clinical placement experience for these students. Instructors were disappointed with the lack of continued support for this program as they felt there was a great deal of interest and need for it in their province; in addition, they would like to have used their experience to improve on the program for subsequent years.

In addition, the Medical Laboratory Technology program at Institution C was funded to develop an 8 week simulation to replace part of the student's clinical placement. This was intended to offload some of the burden of training for clinical practicum sites and was developed as part of a joint simulation program with another medical laboratory program in the province. The proposed curriculum assumed an instructor:student ratio of 1:4. This project, too, did not receive approval or funding for implementation due to concerns regarding the high costs associated with the simulation. Due to space constraints, the current Medical Laboratory Technology program is unable to expand its class size, in the near future, in order to meet the province's demands for more graduates.

Case D

Institution D offers an 'integrated' or 'real-time' model of simulation laboratories in the students' clinical year. The dedicated student laboratory spaces (one for each of the five laboratory disciplines) are located adjacent to, or in the vicinity of, the hospital laboratory to which students will be assigned for their clinical placements. Students may also attend an off-site laboratory for short periods in some of the disciplines. Using a complex scheduling template, instructors assign the students in small groups to a simulated laboratory immediately prior to their clinical rotation in that discipline. Because of the physical proximity to the laboratory, students may rotate back and forth between the simulated and clinical environments. The rotation scheme accommodates the limited space available in the clinical laboratory for teaching students. During their clinical rotation, students still have access to the simulation instructors and facilities when they need assistance. This arrangement constitutes a unique 'just in time' approach to integrating simulation-based learning and clinical education in medical laboratory education.

Three of the dedicated student laboratories are in the hospital itself, and the other two are in a neighbouring building where the medical laboratory program is housed. The laboratories vary in size, with one space a generous 25' x 25' and the smallest somewhat cramped at approximately 10' x 15'. They meet BSL-2 safety standards. The instructor:student ratio is 1:4. The staffing strategy for the simulation laboratories also models a high degree of integration, with both academic and clinical instructors teaching in the clinical environment.

This model has been in existence since the medical laboratory program's inception, and was designed to increase the overall capacity of the clinical site to train the program's students by decreasing the number of students who are in the hospital laboratory at any one time. Students currently participate in a total of 11 weeks of simulated laboratories and 31 weeks of clinical placement. The program will soon shift to 11 weeks of simulated laboratories and 26 weeks of clinical placement.

Case E

Institution E offers a 9-month bridging program for internationally-educated medical laboratory professionals which has included simulated laboratories for 3 years. Although some students choose to opt out of certain parts of the program (if they have prior experience in that area) the majority participates in 1 to 6 week blocks of simulated laboratories, which equals 225 hours and gives the students exposure to 45 hours in each of the 5 traditional disciplines. The students then go out for 2 to 6 week blocks to a clinical institution for placements that total 18 weeks.

The laboratory facilities are located on two different campuses 20 minutes apart. Space constraints present challenges: at least one of the rooms used for simulated learning activities does not meet BSL-2 specifications (it is a traditional classroom, approximately 20' x 20', rather than a laboratory), which places serious restrictions on the types of activities that can be facilitated and the types of materials and equipment that can be used. As well, staff often must transport equipment and materials between the two sites. Instrumentation is fairly basic. The instructor: student ratio varies from 1:8 to 1:9.

Case F

Institution F has offered simulation laboratories for 4 years in its bridging program for internationally educated medical laboratory technologists. This program also serves a refresher function for those wishing to re-enter the profession. As well, the institution's full-time medical laboratory program will include simulation laboratories in the 2007-8 academic year.

The bridging/refresher program is offered in modules which the students can select according to their need. Not all students select the simulation laboratory module as it is not required for professional certification. Declining student participation in the simulation portion of the program is a concern, as minimum numbers must be maintained to make the laboratories financially viable. The bridging/refresher program runs from September to May on Thursday and Friday evenings, and full days on Saturdays and Sundays. Simulation laboratory instructors are practicing medical laboratory technologists. The laboratory rooms and equipment are the same as those used by the institution's full-time program; they are approximately 20' x 40' in size and are BSL-2 compliant. These simulated laboratory activities resemble the academic lab exercises of the full-time program but bring in some aspects of authentic laboratory operations, including specimen volume, stressors, quality control, documentation, a focus on turnaround time, and independent work. Most instructors in the simulation laboratories have full-time employment elsewhere and supervise in the educational institution on their own time. The institution would like to take more students into its bridging/refresher program as there is a great deal of interest in it, but there is no funding to do so.

Institution F's well-established full-time program curriculum has recently been re-designed to include a 15-week simulated laboratory experience in a two-phase block rotation format: students rotate through each of the five areas once, and then through each once again. The rotation schedule is not final and may change; however, the 15-week simulation semester is a given. The simulation semester also includes 2 Interprofessional Collaboration courses with students from other programs. The planned instructor: student ratio is 1 instructor to 9 or fewer students and will necessitate hiring additional staff. This simulation will take place at the end of Year 2 and will be implemented for the first time in May 2008. The clinical placement, which follows in the fall of Year 3, is being reduced from 36 weeks to 22. The curriculum changes are part of the institution's overall shift to a focus on interprofessional education, for which Institution F has received $1.35M funding from the province's health ministry. Also planned is a renovation of the building to include two floors of simulation suites to be utilized by the institutions health professional programs. As well, the institution also hopes to create a 'core lab' environment for its simulations, but the funding for this has not yet been identified and the program's current laboratory facilities will be used for its simulations. The institution's current levels of laboratory technology are thought to be adequate but there are hopes to implement a hospital information system and to make a shift to digital imaging technologies where applicable. The institution also hopes that the curriculum changes will address its increasing challenges with obtaining sufficient numbers of clinical placements for its students. The simulation laboratories in the medical laboratory program are part of a strategy to enhance student preparedness for the clinical setting; students who do not meet performance criteria will not be permitted to enter their clinical year until ready, and will be provided with remediation opportunities.

Definitional issues

A major goal for this study was establishing/uncovering a common definition for simulations in medical laboratory education. It is apparent that medical laboratory programs have offered some degree of simulations since they were first brought into the college-based didactic environment from their hospital origins: all courses have traditionally been accompanied by laboratory sessions in which students conduct analyses, like those performed in clinical laboratories, on 'doctored' or 'mock' specimens. Such laboratory sessions are typically limited in duration (two to three hours) and scope (one procedure at a time in one subject area at a time, such as chemistry or microbiology). The procedures may not necessarily represent state-of-the-art technology, but are considered to impart the necessary foundations for theoretical understanding and manual skills. They may be considered 'low level simulations'. As well, three medical laboratory programs have used simulations for decades. Therefore, it is important to keep in mind that simulations are not a new development in medical laboratory education. In this report, the traditional low-level simulations are considered to be part of the basic academic laboratories used by all medical laboratory programs, and are referred to as 'academic' laboratories.

What is apparent in the responses of this study's participants, however, is that there are pressures and expectations for the traditional model of academic laboratory activities, which for most programs are the major laboratory experience facilitated for students, to expand into a different and higher-level type of simulated learning experience. This study has explored these driving forces as well as the types of learning activities that have resulted.

A number of characteristics of simulated laboratories were evident in respondents' comments with respect to the newly-emerging simulated laboratory construct. Authenticity of the experience appears to be the major criterion for these laboratory sessions. With the exception of one program, these simulation-based learning activities take place in the educational institution but recreate the environment and experiences of the clinical site as closely as possible with the available resources. The overall characteristics and expectations for these simulation activities can be grouped into these categories:

- **Workload and workflow:** immersion in environments with large specimen volumes, workloads and work flow (in some cases, a full 8 hour work day); use of real patient specimens;
- **Technology**: use of current analytical technology and procedures: computers, phones, and a laboratory information system;
- **Task complexity**: increasingly challenging tasks at a faster pace; introduction of work environment stressors such as distractions (for example, phone calls and other interruptions); recreations of authentic situations (such as priority and 'stat' testing); multi-tasking and troubleshooting;
- **Task breadth:** a continuum from specimen procurement, data entry, testing, resulting, reporting; reagent preparation, instrument maintenance, troubleshooting, quality control, safety, interpretation and decision making; multi-disciplinarity (for example, a 'core laboratory' environment); interaction with other health professionals;
- **Pedagogical strategies:** experiential learning; problem-solving in a case-based environment to permit integration across laboratory disciplines; a focus on process rather than on product; high level of instructor supervision, interaction, and feedback; creation of a safe learning environment; situational responsiveness and flexibility (ability to alter pace, tailor tasks, provide individual attention); explicit application of theoretical concepts to bridge didactic (theoretical) and clinical (practical) elements of the curriculum; encouragement of increasing student independence in decision-making; review and extension of previously-learned skills and knowledge.
- **Learning space**: laboratories in the educational institution are *always* considered to be simulated, as are virtual environments regardless of the site; once the student is in the clinical environment, *some* activities are considered simulated if they do not contribute directly to laboratory operations or data provision (i.e., if their sole purpose is as an educational tool).

These characteristics notwithstanding, it is not clear that all programs are interpreting the term 'simulated laboratories' in the same way, nor do all programs describe their simulations using all of the characteristics mentioned above. For some programs, 'simulated laboratories' are simply an extension or a re-naming of the low-level simulations that have traditionally been in use for the four to five decades that medical laboratory programs have operated within a college setting. Several programs did not self-identify in the initial survey as offering simulation laboratires, but it became apparent that their student laboratories demonstrated some of the characteristics of simulation-based learning. Some programs are not in a position to implement high-level technology but nonetheless create as authentic a laboratory environment as possible for their simulation-based activities.

It is very clear, as well, that laboratory simulations in medical laboratory science are very different from those in medicine and nursing, where the term 'high fidelity' indicates use of sophisticated computerized patient simulators. Since medical laboratory work does not involve extended patient contact, medical laboratory programs may make use of 'high technology' and a great deal of authenticity without fitting the commonly accepted definition of the term 'high fidelity'.

Respondents reported that simulated laboratories are also known by these names: simulated clinical, simulated clinical practicum; teaching labs, student labs, simulated clinical experience, simulated Canadian experience; performance activities; *situation problème finale*; *apprentissage simulé*.

The inquiry for this study has resulted in this working definition: Simulation-based medical laboratory education provides a controlled virtual, or simulated environment that reproduces the clinical laboratory environment to some extent in order to permit learners to integrate theory with hands-on skills, to practice and master skills, and to be assessed applying these skills. It is characterized by workload and workflow, technology, task complexity, task breadth, pedagogical strategies and learning space that prepare students for work in a clinical laboratory.

Implementation characteristics of simulated laboratories

Analysis of the ways in which current medical laboratory programs have implemented simulations have revealed some commonalities and differences in how they are implemented.

How simulated laboratories fit into the curriculum

Historically, medical laboratory programs originated as apprenticeship experiences in hospital laboratories. In the 1960s and 1970s, most programs shifted the academic portions of their curricula into community colleges or technical institutes, leaving the final portion of the program of up to a year in length for a clinical placement in the hospital setting. (Clinical placements have decreased in length to varying extents since that time.) Communication between the two learning environments and the accountability for funding for these processes have not been implemented with much clarity and success, and still remain obstacles to effective and prompt decision-making for medical laboratory education.[5]

Full-time programs that make use of simulated laboratories generally schedule them after the students have had a major portion of their theoretical program and basic academic laboratories but before they begin their clinical placement. In the case of one program for internationally educated medical laboratory technologists, the simulated laboratories took the place of a clinical placement. ‘Block scheduling’ – sequential scheduling of simulation laboratories in each of the five laboratory disciplines, one after the other – is the most common model. However, as described in one of the case studies, Institution D uses what could be referred to as an ‘integrated’ model of simulations; in this case, students complete a period of simulation labs in one discipline, then immediately enter the clinical environment for their clinical experience in that discipline. In the case of one bridging program for IEMLTs, students choose their simulation experiences from what can be considered a ‘modular’ format: they take only the modules that they need to upgrade their prior experiences. Only one program, again, a program for IEMLTs, has crossed disciplinary boundaries in its ‘core laboratory’ setup, where students carry out exercises in multiple disciplines (chemistry, hematology, and blood bank) as would occur in a typical large central laboratory setting. (Although one coordinator who did not initially identify

[5] Grant, M. M. & Davis, K. H. (2004). Cited previously.

her program as offering simulated laboratories did note that the curriculum includes a core lab experience for students.)

Four ways in which simulation-based activities could be implemented in medical laboratory education are pictured in Figure 1.

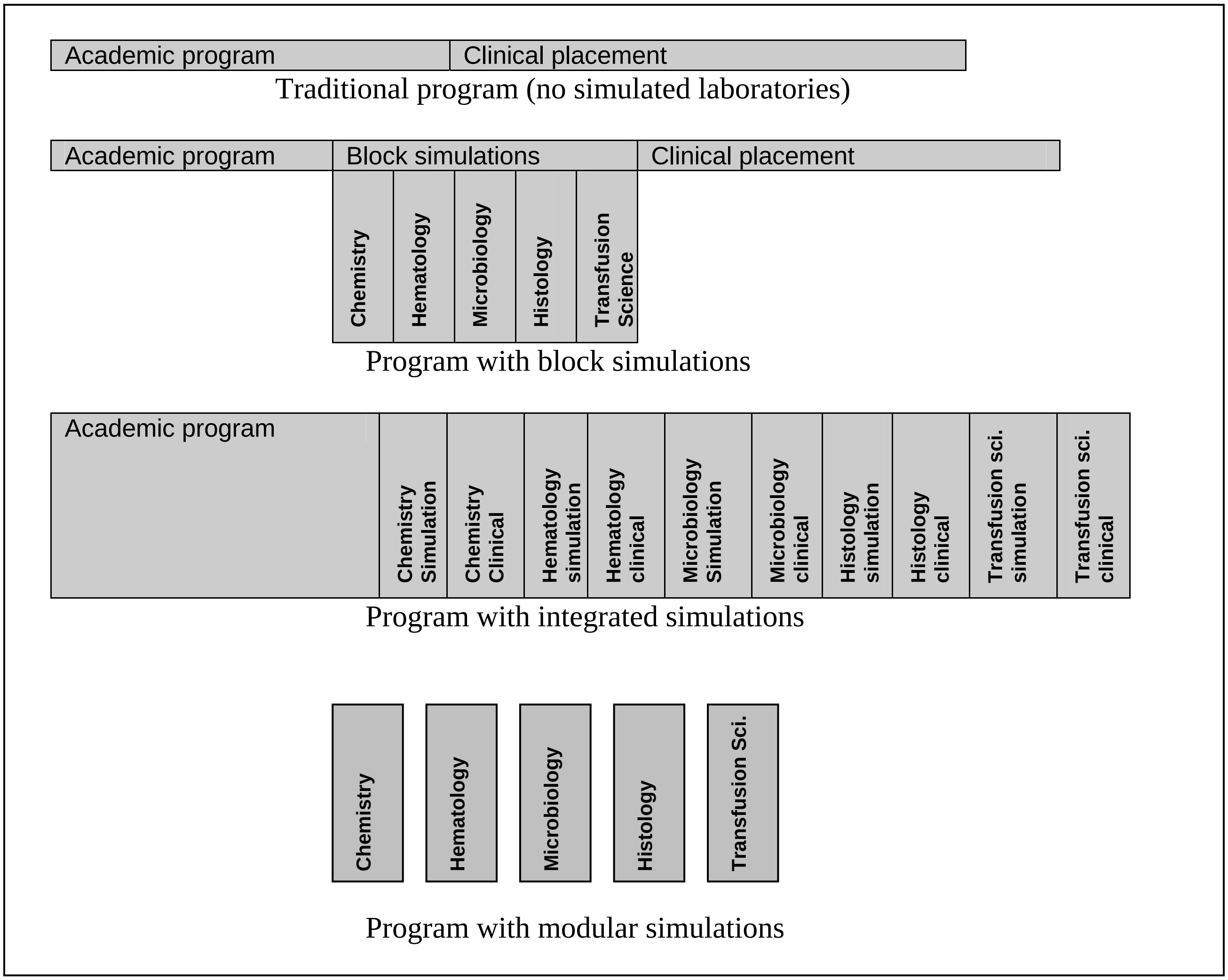

Figure 1: Four ways in which simulated laboratories may be scheduled within a medical laboratory curriculum

<u>What typically happens in a simulation laboratory?</u>

Most simulated laboratories take place in fully-equipped student laboratories in the educational institution. They usually start first thing in the morning and last the full school day (6 hours) or work day (8 hours). These attempts to approximate a full work day are the most obvious of the differences between simulations and traditional academic laboratories, and appear to differ from models for simulations used in other professions.

Students may work individually or in small groups. They may begin the day with a mini-lecture, video or demonstration by the instructor, new or review material on theory related to the procedures of the day, or orientation to particular technical aspects of the day's activities. There may also be seminars, student presentations, or student assessments (written and practical). Once the hands-on part of the laboratory begins, students receive a batch of specimens in the mornings and develop or have given to them a work list to take them through the day. Most routine laboratory procedures have been adapted to simulated laboratory use. A full list was included in this study's Phase 1 report. The overall goals of the simulation laboratories appear to be expanding and refining students' technical skills as well as encouraging them to demonstrate an increasing degree of autonomy, professionalism, and discretionary judgment in their laboratory tasks.

While some sessions may involve all students performing the same activities at the same time, limited availability of certain equipment may require that students rotate through several workstations. Workstations may involve automated or manual testing procedures; instructors attempt to maintain as high a level of hands-on activities as possible, but students may also work on readings, assignment questions, watching videos, completing online learning modules, and working on case studies at the workstations. Small or large group discussions may also take place during the day in order to share information or debrief learning activities.

Over the course of days or weeks, the activities are designed to offer opportunities for cumulative skill-building, time management, and multi-tasking. Instructors gradually introduce increasingly complex methods or cases. For example, activities may progress from manual to semi-automated to fully-automated procedures, or from single-technique to multiple-technique and sequential processes. Some instructors opt to introduce automation at the start. However, manual methods are considered by most simulation instructors to impart superior appreciation in students of the theoretical foundations for the method, and are often preferred or necessitated because of their lower cost as compared to automated techniques. Factors that go into selecting activities to be simulated include:

- the complementarity of academic/clinical settings: for example, activities that cannot be carried out in the clinical site;
- commonality: routine procedures with relevance to all clinical sites;
- program priorities: for example, established competency based objectives;
- repetition: activities that need time for students to practice repeatedly;
- availability of resources: equipment; samples; supplies; space; instructors; support & education for staff;
- the needs of clinical partners for students with specific skills;
- the validity of the learning experience: its potential for authenticity; the likelihood of minimal compromise to quality of the student experience; evidence of effectiveness relative to the effort and cost involved.

As one simulation instructor noted, the choice of what gets simulated often boils down to this:

> ***We do what we can do at the school well and let the practicum in the hospital do what they can do well.***

While some instructors focus on repetition of certain skills, others feel that breadth of experience is valuable, suggesting that learning different principles is more important than seeing variations of the same thing. In the latter case, instructors will provide activities that expose students to as many methodologies and variations as possible.

Tasks are designed around the competencies outlined in the CSMLS national competency profile[6] and are allocated to the simulation labs in consultation with clinical partners. Simulation instructors may 'sign off' on some of these competencies in the simulation laboratories (meaning that they will document that students have successfully demonstrated the acquisition of the required competency at the simulation stage of their training and do not need to demonstrate it or be evaluated on it again prior to their certification examination).

Particular strategies or activities employed by instructors to facilitate the teaching and learning processes include the following:

- peer teaching;
- use of simulated worksheets or virtual computer/laboratory information systems;
- use of unfamiliar terms on requisitions;
- student presentations;
- having students do lab prep work (preparing/labeling specimens, etc.) and preparation of documentation (such as protocols, MSDS precautions for chemicals, and maintenance records)
- emphasizing workplace protocols and activities, such as laboratory accreditation standards.

The use of computer-based learning and digitized media was also referred to by some of the participants. E-learning systems, online tests, computer simulations, digitized media (i.e., microscopic slides) and other learning management systems are used to introduce students to laboratory safety, quality management, interpretation of microscopy slides, and data entry skills. Some simulation instructors utilize online learning tools as part of the workstation activities through which students rotate during their simulation laboratories; the WebCT learning environment is used by several institutions. Many texts and self-paced learning programs are packaged with CD-ROMs or case-based learning tools that are described as 'simulations'. The following products were mentioned by name:

- HyperLink 2: interactive case studies in microbiology;
- Hematography Plus, (2007, University of Minnesota): hematology slides;

[6] Canadian Society for Medical Laboratory Science. (2005). Competencies expected of an entry-level medical laboratory technologist. Hamilton ON: CSMLS.

- Diagnostic skills in clinical laboratory science (2004, McGraw Hill): case studies across the disciplines;
- Microbes in Motion (2004, WCB/McGraw Hill): basic microbiology with animation;
- MediaPhys: Introduction to Human Physiology (2005, McGraw Hill);
- Urinalysis (Bayer Inc.); a urinalysis atlas;
- Hummingbird (LCI Inc.): computerized laboratory information system (LIS);
- Other tools: Camtasia Studio (2007, TechSmith), a screen capture application for creating demos and training materials; Captivate software (Adobe) for creating computer simulations and scenario-based training.

One clinical educator demonstrated a computer simulated 'mirror' of the hospital's laboratory LIS that permits students to familiarize themselves with the hospital's LIS and avoid risking error or damage to patient data on the real LIS. He considered such applications to be a good example of 'just in time teaching': the computer simulation programs he described were used in the clinical environment to allow students to access particular types of information or skills when they need it most (but not to shorten or replace clinical education). Many of these resources are used by students both in the simulation and clinical phases.

However, despite the availability and utility of such computer-based simulations, participants' overall responses suggested a definition of simulation laboratories that recreate at-the-bench activities. Computer simulations were viewed as an adjunct to hands-on learning in the simulated or authentic clinical laboratory setting. They can impart knowledge and allow students to hone their clinical judgment skills, but computer simulations were clearly conceptualized as distinct from the 'simulated laboratory' construct and the acquisition of practice-based skills.

Simulation instructors assess students' knowledge, skills, and attitudes through written, practical, and computer-based tests. Students may also do self-assessments, take-home assignments and reports, and benefit from ongoing feedback and goal-setting. Simulation instructors who utilize debriefing sessions at the end of each day feel very strongly about their value for learning, critical thinking, reflective practice, and student assessment.

Rationale for use of simulations

Respondents provided a number of reasons that simulated laboratories are being used in their programs. Challenges with clinical placements were mentioned most frequently as motivating factors for implementation of simulated laboratories, even in programs that have had their simulation laboratories in place for 25 years or more. Respondents reported using simulated laboratories in order to:

- compensate for a short practicum, to permit shortening an existing practicum, or to otherwise facilitate the scheduling of clinical placements;
- permit placement of increased numbers of students;

- enhance students' knowledge, skills and attitudes to a standard acceptable for clinical site and thus to ease the work of preceptors;
- expose students to situation/cases that may not occur during their clinical placement;
- provide a venue for learning experiences that are increasingly difficult to facilitate in the clinical setting (i.e., histology, microbiology, transfusion science);
- provide orientation to Canadian health care practices, environments, and skills expectations for internationally-educated medical laboratory technologists;
- facilitate consistency in teaching, learning, and student assessment.

Pedagogical validity was rarely cited as contributing to the shift to simulation-based learning and most educators were not aware of any literature that would provide an evidence base for use of these activities in medical laboratory education.

Patient safety was also not mentioned at all as a motivating factor for implementation of simulations. This latter point marks a clear difference from the medical literature in the rationale for use of simulations, but it should not be interpreted as an indication that patient safety is not a concern to medical laboratory professionals. It simply extends from the fact that the most common form of direct student contact with patients is venipuncture (blood-taking); medical laboratory students have traditionally been well-prepared for this with simulated and 'real' practice sessions before they encounter patients in the clinical setting. As for laboratory test results, students in the clinical setting do not issue patient results. All laboratory results are signed off by practising technologists. Therefore, the presence of students in the clinical environment does not pose a threat to patient safety and moving student education to a simulated environment does not offer any improvement to patient safety.

Advantages cited for simulation laboratories

According to the participants in this study; simulation-based learning activities in medical laboratory programs have positive features that fall into six main categories:

- They enhance the quality of the learning environment.
- They facilitate student acquisition of crucial knowledge, skills, and attitudes.
- They provide opportunities for assessing students.
- They enhance the uniformity of the overall learning experience for all students.
- They have benefits for clinical partners.
- They may facilitate addressing health human resources shortages.

These points are discussed in greater detail, below.

Simulations enhance the quality of the learning environment

- The relaxed environment (relative to the clinical setting) is conducive to good learning experiences.

- Simulations provide a psychologically safe environment for making mistakes and for learning potentially anxiety-provoking skills (for example, venipuncture).
- Simulation permits learning laboratory skills in a pedagogically-informed environment (technologists who work with students in the clinical setting may not necessarily have training as educators).
- Given a favourable instructor:student ratio, instructors in simulation laboratories give students more individual attention; instructors are more available to answer questions (clinical instructors' attention must sometimes, of necessity, be on their work responsibilities), whereas simulation instructors can stop everything to take advantage of 'teachable moments'.
- Simulation-based activities make optimum use of educators' skills: didactic instructors can focus on theory as it relates to specific skills in the simulation, leaving clinical instructors to focus on technique in the clinical environment (the 'best of both worlds for students', as one participant put it).
- Simulations provide an ideal setting for bridging the gap between theory and practice.
- Learning activities in simulations are consistent with educational theories of experiential learning and of learning as a social activity.
- Simulations offer a broader, more sustained experience than is possible with traditional 2- or 3-hour student laboratories.
- The extended or full-day format enables protracted discussion and learning activities, and authentic immersion in technical processes.

Simulations facilitate student acquisition of crucial knowledge, skills, and attitudes:

- Students get more hands-on opportunities: for example, with instruments that could not be shut down or opened up for teaching purposes in the laboratory; in the clinical environment, students are often confined to watching.
- Simulation provides opportunity for practice, repetition and remediation.
- Simulation-based activities offer students an opportunity to work with more complex specimens (for example, mixed microbiological cultures).
- In simulated laboratories, students become immersed in the subject matter and can progress to a higher level of competence.
- The skills learned in simulations are readily applied to small centres with manual methods and older equipment.
- Simulation creates an ideal environment for teaching/introducing safety and workplace precautions and policies.
- Simulations can prepare students well for the expectations and responsibilities of the work place.
- Simulation-based learning enhances student confidence and morale, putting them in a good position to weather the challenges and occasional discouragements of the clinical setting.
- Simulations offer opportunities for students to assess their own abilities and to see their own progress.

- Simulations are ideal for giving students an overview of the laboratory operations and of fundamental skills (i.e., manual procedures and the basics for understanding automation).
- A simulated laboratory is a good environment for fostering skills such as professionalism; blood collection; safety; technical skills; multi-tasking; organization; time management; teamwork; communication and other soft skills.
- Simulation capitalizes on certain readily-simulated topics, for example, urinalysis, LIS, data entry.
- In simulated laboratories, instructors can manipulate the pace, complexity, urgency and stress of the learning activities and environment; higher expectations are possible because the situations are controlled and consequences of errors are minimal.
- Simulations are efficient, as one simulation laboratory can expose students to as many procedures as could be dealt with in 5 or 6 traditional academic laboratory sessions.

<u>Simulations provide opportunities for assessing students and providing feedback</u>

- Student difficulties with language, communication, and interpersonal interaction show up more readily in the simulated setting (particularly useful for internationally-educated students).
- Instructors can assess students' capacity to function independently.
- Success in simulated activities may be a predictor of student success in the clinical setting.
- Instructors may 'sign off' on some competencies so that they do not need to be dealt with during the clinical placement.
- Simulations may encourage students to take more responsibility for their own learning through self-evaluation and goal-setting.
- Simulation laboratories offer opportunities to identify weak or struggling students and time for remediation prior to the clinical placement; mechanisms for subsequent monitoring during the clinical placement can also be put into place.
- In simulations, students can be assessed performing procedures that use authentic materials (i.e., instruments and patient specimens).
- Simulations may enable instructors to identify undesirable student behaviours (dress, safety, and other elements of professionalism) and to give students a chance to improve before their clinical placement.
- Small group discussions and debriefing sessions of simulations identify students who are not well-prepared.

<u>Simulations enhance the uniformity of the overall learning experience</u>

- They provide all students with exposure to procedures that might not be available in all clinical settings, resolving the sometimes 'hit and miss' nature of clinical placements.
- They create uniform conditions for assessments.

Simulations have benefits for clinical partners

- They ease the students' transition into the workplace.
- They facilitate better use of resources at the clinical site, for example, by reducing the amount of time that clinical instructors must spend reviewing theory and basic concepts.
- They bring students to a minimal level of competence that meets the expectations of clinical instructors.
- They increase acceptance of students by technologists and employers in the clinical setting.

> ***We found that many employers were more willing to provide the 12 weeks of clinical after the students had gone through the simulated clinical.*** (Director of a program for internationally-educated medical laboratory technologists)

The phrase 'easing the burden of clinical education' was used or alluded to by more than one instructor as a goal for simulation laboratories.

Simulations may facilitate addressing health human resources shortages.

The limited number of clinical placements functions as a bottleneck for most programs that are under pressure to increase their class sizes and produce more graduates to meet workplace needs. Some programs also face additional class size ceilings due to laboratory and classroom space in the educational institution. The program coordinators of two programs see their revised simulation-based curricula offering the potential to produce more graduates and meet increasing human resources demands for medical laboratory technologists: they propose that simulation laboratories allow them to shorten the clinical placement portions of their programs to the point where they can offer a dual intake (i.e., two classes per year), assuming the appropriate funding and other resources are in place.

Challenges/limitations of simulations

Study participants identified a number of concerns about simulation-based activities in medical laboratory programs. These can be placed in four main categories:

- They are demanding for instructional staff.
- They are resource-intensive.
- Some aspects of laboratory work are difficult or impossible to simulate.
- The quality of the learning experience may be uneven.

These points are discussed in greater detail, below.

Simulations are demanding for instructional staff

Simulation instructors maintain a hectic pace of early mornings, missed lunch breaks, late evenings, marking assignments at home, specimen pick-up from clinical sites, and all-day interactions with students. The time commitment, level of responsibility, physical demands, setting up role play scenarios, unexpected need for remediation, and unpredictability of simulation laboratories can be anxiety-provoking and unsustainable. This is particularly the case the first time simulation laboratories are implemented; in later iterations, instructors benefit from prior experience and the resources that have already been created. Generally, simulation instructors must forego or postpone other responsibilities and possibly family or social commitments while they are conducting simulation laboratories. Block simulation laboratories are thought to monopolize instructor time so that they are not available for other educational functions, let alone personal ones.

In situations where one instructor must supervise more than 5 students, laboratories become increasingly rushed and instructors express worries about student safety and quality of the learning experience when they are not available to help or answer questions. Adequate supervision is essential when students are working with biohazardous materials (including specimens that may present risks for HIV or Hepatitis transmission) and potentially dangerous mechanical and electrical equipment. The integrity of costly laboratory equipment may also be at risk when there aren't sufficient instructors to supervise adequately: one simulation instructor described a situation where a crucial $900 instrument component was damaged because the student using it did not have sufficient supervision. The part could not be replaced and the other students were unable to complete the assignment with the instrument.

Students identified activities such as reading hematology slides as tasks where they would like to have one-on-one instruction from their instructors. The students in the one program with instructor:student ratios of 1:4 give uniformly positive responses about instructor availability.

I liked the constant feedback. You can always find someone to help you in the simulation lab. [Student in a simulation laboratory with a 1:4 instructor:student ratio]

Even then, the simulation instructors in this program feel the weight of responsibility, as each is the only person facilitating the simulation and each has other teaching responsibilities as well. When instructors have overlapping responsibilities (for example, administrative duties or other classes to teach) they occasionally are required to leave the laboratory, further depleting the laboratory staffing levels or leaving students unsupervised. The lack of back-up personnel is a real concern for instructors.

If one of us gets hit by a bus, there's going to be a real problem here because there's no one else to take over. [Simulation instructor in a program with a 1:4 instructor: student ratio]

Simulation laboratories where there are more than 6 students per instructor prompt consistently negative comments about instructor availability from simulation instructors and students, although it should be noted that students are appreciative of the instructors' efforts to give them whatever attention they can. One simulation instructor noted that, for a simulated laboratory to successfully simulate the clinical environment, it should also reproduce the instructor staff ratio of the clinical environment, which is usually 1:1 or 1:2. She suggested that once the number of students per instructor is more than 7, the laboratory environment resembles a traditional academic laboratory rather than a simulation laboratory and many of the benefits of a simulation no longer apply. There appeared to be a general consensus across the institutions that a 1:4 or 1:5 instructor-student ratio would be optimal. A ratio of 1:5 appears to be a 'threshold' value for an optimum teaching and learning experience.

But effective supervision of simulation laboratories involves more than just the right number of 'bodies' to create an acceptable supervision ratio. The expertise and skills mix of the simulation instructors must be appropriate. One of the essential skills repeatedly mentioned by simulation instructors is adaptability: a simulation instructor must be able to react in a constructive way to situations that do not work out as planned.

Each time the simulation is run, it is different. … We can't always give the students real specimens, or sometimes the ones we've prepared don't work out as planned. … We often have to compromise or invent or get the students to imagine 'what if' to get the point across. (Simulations instructor)

An additional, and crucial, requirement is experience with the laboratory subject matter. As in other professions, medical laboratory technologists often find themselves gravitating toward an interest in one of the five sub-disciplines of the profession; after some time working in that area, they are inevitably less comfortable dealing with the other areas. Some programs bring in technologists from the clinical setting to teach or assist with their simulation laboratories and are able to capitalize on the instructors' current familiarity with workplace demands. Students complain about the presence in the simulation laboratory of instructors who are unable to answer questions and must, themselves, wait for the specialist instructor to be available.

There were not enough instructors. The backup instructors didn't have enough expertise. A 3:21 ratio is really not 1:7. (Student speaking about a laboratory with 3 instructors and 21 students).

A 1:7 ratio would be fine if all the instructors had appropriate experience. (Student speaking about a simulation laboratory with a 1:7 instructor:student ratio)

Preparation for simulation laboratories is demanding: it involves a great deal of specimen handling (including picking up and transporting samples from local hospitals), specimen preparation and testing, equipment testing and maintenance, paperwork, creation of documentation associated with laboratory procedures and quality control), curriculum development. Some programs have support personnel (laboratory assistants, teaching assistants, technicians) to assist with some of these duties.

Burnout and fatigue were the major source of concern expressed by simulation instructors in discussing their experiences. They found that simulated laboratories, while rewarding and apparently effective teaching activities, were also an unhealthy and unsustainable activity. Both instructors and students expressed major doubts about the educational value of simulation laboratories when staffing levels are not adequate.

Simulations are resource-intensive

Participants were unanimous in their recognition of the high demands that simulation-based activities make on educational resources. In effect, educational institutions are attempting to re-create a hospital laboratory at the educational site and this appears to be rarely acknowledged when resources are allocated to the program. The resources about which instructors expressed difficulties were funding; equipment; specimens; space and scheduling, and administrative support, in that order of importance and frequency of mention.

Funding: Because, in most cases, the costs of simulation laboratories were built into the costs of running the program in general, it was difficult to isolate the exact costs of simulated laboratories alone. This is further complicated by the fact that, despite the similarities among the programs' simulations, there were subtle differences in the ways the simulations were operationalized that would introduce variations in costs.

Nonetheless, it is clear that simulation laboratories are expensive; all simulation instructors expressed concerns about their costs. Several participants from different institutions noted that the program's simulated laboratories were "the most expensive part of the program" and that the medical laboratory program was the most expensive program offered by the institution. It is significant to note that one program is terminating its simulation laboratories because the institution can no longer afford to offer them; another institution was unable to renew the funding for its pilot simulation-based program because the cost was viewed by the expected funder as too high; yet another program was unable to get the go-ahead funding for its revised curriculum, which included new simulation laboratories, because its cost was unacceptable to the funding agency. The one program that is going ahead with a new large-scale simulation is able to do so appears to have linked its incorporation of simulations into the medical laboratory program to its institution-wide interprofessional education project, for which it has been handsomely funded.

Some programs were able to provide figures that suggest the costs of simulations. One program coordinator estimated a cost for capital expenditures for the first year of its program, which included 22 weeks of simulation for 21 students at $300,000. For another program, operating expenses for 8 weeks of simulation for 24 students was conservatively estimated at almost $30,000, with a total cost for $800,000 for the first year of this new curriculum. Another estimated a cost of $5,000 for reagents and almost $17,000 for instructors for 6 weeks of simulation.

The costs of running simulated laboratories appear to be related to the analytical technology required. The instrumentation is a major start-up and ongoing capital expenditure. Items such as microscopes must be replaced on a regular basis because they are used very frequently. Diagnostic technology has a very short lifespan and rapid obsolescence. Many programs benefit from donation of used equipment by hospital laboratories and they maintain a 'wish list' of items that they will purchase if funding becomes available. Computers and a laboratory information system are often at the tops of these lists. Budgets are prioritized on the basis of student safety and how best to meet the competency requirements for the program. Because of their costs, medical laboratory programs are constantly being scrutinized and coordinators are asked to rationalize their budgets. Overall costs for programs are increasing dramatically, especially with outside pressures to purchase and maintain up-to-date technologies, but program budgets are not, and in some cases, are being cut back.

Operating costs for this kind of educational setup are enormous: reagents, media, and expendables for the automated and manual testing procedures are extremely costly. These items are often proprietary and must be purchased from sole suppliers with no option for competitive bidding. Instruments, whether purchased or donated, require service contracts and repairs. Even when educational institutions are able to partner with clinical sites to benefit from volume discounts on reagents, expendables and service contracts, they still pay more than the costs for equivalent products purchased for the clinical partner. One academic instructor pointed out that the use of reagents in the clinical setting produces patient results, so there is a health data outcome for the cost of the reagents; however, in the simulated laboratory, using reagents could be considered a 'waste of money', since the educational value of the process is not measurable. Nonetheless, simulation laboratories cannot be implemented without a significant and ongoing investment in equipment, reagents, media, and expendables.

Program coordinators commented on the pressures from students and clinical partners for educational programs to maintain relevant and current technologies and to increase the authenticity of simulation laboratories. At the same time, they noted, it is becoming increasingly difficult to rationalize the high cost of their program. The majority of simulation instructors felt the need to shift the emphasis of their simulation laboratories to manual and small automated methodologies and leave the high-technology to the clinical environment. They felt that this is the best way to work to the program's strengths.

One survey participant reflected that simulated laboratories lose money, and that it is not possible to recover the costs by charging students. Another participant stated the opinion that it is more expensive to run simulated laboratories than to send students out to a clinical site for the same length of time. This sentiment was echoed in other participants' comments.

Both capital and operating costs appear to be a major consideration in implementing simulation laboratories. The experiences of the participating institutions would suggest that sufficient start-up and, more importantly, on-going funding, are key in the sustainability of simulation-based laboratories.

Equipment: Simulation instructors, students, and clinical instructors stress the need for up-to-date and relevant laboratory equipment for the students to work on. Computers (including good educational resources) and laboratory information systems were the two types of technology for which they expressed the greatest need in simulation laboratories. Students described the greatest feelings of inadequacy when it came to their clinical experiences in the highly automated areas of the laboratory, particularly the chemistry department, and they wished they could have been better prepared for working with the analytical technology. However, they and most other study participants were willing to concede that it is not possible for educational institutions to purchase and maintain the level of technology found in clinical laboratories, particularly in light of the rapid obsolescence of laboratory instrumentation. Instruments used for educational purposes do not receive the maintenance and consistent use that takes place in the clinical environment, and their high cost and rapid obsolescence make them a poor investment. At least one program coordinator noted that the institution has difficulty getting instrumentation serviced as there are few service representatives in that part of the country. Reagents and other expendables for these instruments are also at a premium and programs use outdated reagents when they can to cut the cost of running their instruments.

The integrated model for simulations, where the students are already in the clinical environment, appears to be an efficient means of avoiding duplication of resources since students can go ‘next door’ to observe instruments and there is no need to equip the simulation laboratory to the level that would be required if the simulation was taking place off-site. The overall consensus of study participants was that simulation laboratories were best applied to manual, semi-automated and compact/small fully automated methodologies as long as the relevance of these procedures is high. The clinical placement was seen as the best environment for students to learn about larger and more complex technologies.

Specimens: Authentic specimens are extremely difficult to obtain. Simulation instructors are quick to express their gratitude to clinical partners that supply them with specimens. They report using outdated control samples, abnormal sera, urine samples, stained slides, throat swabs, sputums, stools, EDTA samples, smears, fresh samples, and autopsy specimens donated by hospitals.

However, the number of specimens that instructors can obtain usually is not sufficient to effectively mimic the workload levels of the clinical setting, nor does it offer the variety needed to expose students to a breadth of clinical pathologies. Every participant in this study cited specimen volume (i.e., the total number of specimens tested) as the primary characteristic of simulation laboratories that falls short of re-creating an authentic clinical environment. Significantly, this is one of the major characteristics of transitioning into the clinical environment for which students say they feel the least prepared.

It is worth noting that transporting biological materials from hospitals to educational institutions presents challenges and must adhere to standards for transportation of dangerous goods. As well, two instructors pointed out emerging concerns about the ethical issues of using patient specimens for student testing (even though all identifying information is removed from each specimen before it is given to the students). Other concerns include that real patient specimens deteriorate, or may become contaminated and that it is extremely difficult to simulate certain rare or specialty specimens (for example, antibodies or abnormal and borderline specimens).

Some products can be purchased and used for simulated specimens but they are costly. Instructors find the preparation of ‘faked’ or ‘doctored’ specimens time consuming and challenging, and not always successful. The specialized equipment for preparing large quantities of specimens may be too costly to purchase. Simulation instructors note that some types of specimens just cannot be simulated (cerebrospinal fluid and certain microorganisms were mentioned more than once in this regard.) Blood products for teaching transfusion science procedures are not available. In order to supplement their supply of blood specimens, simulation instructors frequently have students collect blood or throat swabs from each other. Staff members outside of the educational institutions’ medical laboratory programs also sometimes generously serve as sources of blood specimens, particularly if they have an unusual blood characteristic that is useful for students to analyze. Both of these resources offer an effective opportunity for the students to practice venipuncture, but there are limits to how often this can be asked of the volunteers. Several simulations instructors said that the lack of appropriate specimens was a significant obstacle to implementing the case-based approach they felt was most effective in simulated laboratories.

Space and scheduling*:* In all of the programs visited during this study, space is a major concern. Although several of the programs are fortunate enough to have dedicated laboratories for their students, others share space with other programs in a somewhat competitive and grudging environment. For example, institution C’s ‘integrated’ simulation takes place in its partner hospital where space utilization is reportedly at 140%; dedicated teaching spaces are at risk for being labeled an untenable luxury and being reassigned. Admittedly, the criteria for safe, functional laboratory spaces make these very expensive for educational institutions to dedicate to one program, but shared spaces present other issues, including the potential exposure of non-medical laboratory personnel to biohazards. Shared laboratories necessitate moving equipment in and out of the rooms, which is hard on the instructors and jarring for delicate instruments.

Many of the laboratories are crowded; students and instrumentation share limited bench space. The laboratory rooms accommodate anywhere from 8 to 32 students at a time; the smaller spaces may necessitate running the lab exercise more than once if the total class cannot be taught all at once. Small laboratory spaces are also a constraining factor for programs that wish to increase their class sizes. At least one of the programs operates a laboratory in classroom space. This places severe limitations on the kinds of learning activities that can be facilitated. It also requires that instructors transport laboratory supplies back and forth between the classroom and another campus 20 minutes away.

Of course, where space is at a premium the logistics of scheduling are considerable. Some medical laboratory programs simply cannot accommodate simulations in their curricula without a major program re-design. For others, implementing simulations involves an intricate scheduling matrix to avoid overlapping commitments and to ensure that all students receive time in the required areas. Simulated laboratories may be offered during summer months or during evenings or weekends to work around the needs of other programs. Preparation and cleanup must be fitted into the short intervals between scheduled use of shared lab spaces. Staff availability must also be considered. Some instructors consider block simulations to be an efficient use of space, resources and instructor expertise, while others see huge disadvantages in their monopoly of instructor time and their perpetuation of a 'silo effect' if instructors do not get an opportunity to work within more than one specialty area.

Integration of medical laboratory programs with other programs (for example, in interprofessional or core health sciences curricula) superimposes another level of complexity on scheduling of laboratory space.

Simulation instructors expressed concern about the rushed nature of some of the simulation laboratories. They regretted that there was no time for remediation ("No time for failures", as one instructor put it) and no leeway for the unexpected (equipment breakdowns, and staff or student illnesses). Time for reflection was also felt to be critical for a positive learning experience. Instructors whose laboratories did not allow for it felt the laboratory was only partially effective; those who had deliberately scheduled debriefings at the end of the school days regarded it as an absolutely essential aspect of the simulation laboratory.

As far as the participants in this study are concerned, there is no doubt that dedicated space for simulation laboratories offers immense benefits, both for the quality of the learning environment and for the efficiencies, convenience, and flexibility it would afford for scheduling and implementing the laboratories.

Administrative support: Though not cited as a main resource, the availability of administrative support was an underlying feature of the work involved in running simulation laboratories. Simulation instructors reported spending many, many hours developing the paperwork and documentation involved in setting up their laboratories (for example, specimen labels, requisitions, and worksheets). One program was fortunate to have the part-time services of an administrative assistant for their work; this program generated 18 bankers' boxes full of paperwork from its simulation laboratories in one year. Another program has a central stores and preparation department to handle reagent preparation and provision of laboratory equipment. Program coordinators commented on the large responsibilities involved in ordering supplies, administering the program, negotiating contracts and funding, and ensuring that other forms of support (for example hazardous waste materials disposal) were in place.

Some aspects of laboratory work are difficult or impossible to simulate

The availability of resources and the unique characteristics of the laboratory environment place constraints on what can be simulated. One academic administrator commented:

If you had enough money, you could simulate anything.

When asked what was most difficult to simulate in their simulation laboratories, simulation instructors were fairly consistent in their replies. Interestingly, when asked what areas of the clinical setting they felt *least* prepared for by their simulated laboratories, students pointed out parallel characteristics, suggesting that these areas merit particular attention in the future for students to benefit from their simulation experiences.

- **the laboratory environment:** one participant referred to the laboratory as 'organized pandemonium'; characteristics mentioned during interviews included the intensity of laboratory workflow; the sense of urgency; the frequent distractions and workplace stressors; test volumes; day-to-day workplace issues; shift work; specific laboratory protocols; stats and other emergencies; noise; troubleshooting under pressure; the big picture of work flow from start to finish; the core lab environment; and the interconnectedness and 'flow' among departments and areas of the lab;
- **specific interpersonal and organizational interactions:** for example, dealings with other health professionals; extended and meaningful patient contact; the challenges of special-needs clients (the elderly, infants, acutely-ill patients); handling disgruntled or uncooperative clients; hierarchical relationships and laboratory politics; the politics of unionized environments;
- **issues of professionalism:** awareness of the consequences of one's actions when performing testing on real patient samples; appreciation of patient confidentiality issues; attaching meaning to the work being done (for example, the impact of laboratory error, significance of findings for the patient, concepts of altruism);
- **certain skills**: multi-tasking, working under stress, problem solving, critical thinking;
- **certain types of laboratory procedures and specimens**: grossing; autopsies; specialized procedures (for example, thin layer chromatography or electrophoresis); working with blood products and certain microbiological or unstable specimens;
- **some high-tech applications**: large analyzers; laboratory computers and information systems; and maintenance and technical support for equipment in isolated regions.

The last two of these items have to do with the availability of costly, technical, or specimen resources, while the other four are more qualitative and, possibly more difficult to reproduce even if the money were available.

The quality of the learning experience may be uneven

Study participants pointed out the following points that require attention in order to improve the quality of the learning experience in simulation laboratories.

- Use of expired quality control materials, while cost-effective, sets a poor example for good laboratory practice, as do the short-cuts and 'make-do' quick-fixes that are often necessitated when appropriate resources are not available.
- Insufficient staffing of laboratories makes it difficult to supervise large groups of students; one-on-one time is needed for certain activities; sometimes there are high-needs students; this takes time away from other students.

- Students express frustration with a lack of attention in understaffed laboratories, with laboratories that are not staffed with knowledgeable and experienced instructors, with insufficient equipment, and with outdated methodologies.
- Insufficient numbers of instructors are also a safety issue, as simulations often involve many students carrying out differing activities at the same time, all of which require supervision.
- Students are aware that the environment is not 'real' and that there are no patients depending on their work; it is difficult to encourage students to attach appropriate meaning to their simulation activities or to take appropriate precautions with biohazardous materials.
- It is sometimes difficult to assess students: small group work is not always appropriate for assessing individuals; it is a challenge to maintain confidentiality of student assessments when they are carried out in an open and crowded learning environment; instructors observe inappropriate sharing of work and a tendency for strong students to 'carry' the other members in their group by doing a disproportionate amount of the work.
- It has not been established whether simulations provide the same quantity or quality of experience as students would have in the same amount of time in a clinical setting.

Educational and evidence-based foundations for the use of simulated laboratories

Respondents cited existing practitioner- and program-based expertise as the most widely-utilized source of guidance and information for implementing simulated laboratories. To prepare for and support their simulated laboratories, participants reported consulting competency based objective documents as well as other programs that are already using simulations. They noted that the recent industry experience of those involved in setting up a simulation laboratory and collaboration with clinical partners were particularly crucial to the success of their simulated laboratory projects.

> ***We use the real world as a model.*** (Simulations instructor)

One program, in the process of implementing an institution-wide simulation-based interprofessional focus, has consulted Dr. Amitai Ziv, founder and director of Israel's Medical Simulation Center, and considered to be a world leader in simulation-based medical education.

The lack of documented, pedagogically validated support material is marked. Interview participants mentioned 'experiential learning' and theories of learning and work as social activities as theoretical principles underlying simulations but did not cite or otherwise refer to the literature. One clinical instructor noted Blackmore's theories of memetic selection and role modeling,[7] which he suggested supports clinical experience (but not necessarily simulations) as an opportunity to pass along professional culture. Only one published resource was identified as specifically referring to simulations, and this document merely offers support for the use of

[7] Blackmore, S. J. (1999). The meme machine: Theories of memetic selection. London: Oxford University Press.

simulations in several professions without providing any guidelines for their implementation.[8] In a presentation outside of this study, one program coordinator described studies being done at her institution that suggest a link between the emotional content of learning to the value of simulations for health professions students.[9]

Evaluating the effectiveness of simulated laboratories

Study participants did not identify research that supports the effectiveness of simulation laboratories. However, they reported the following strategies for evaluating their simulated laboratory experiences:

- employer satisfaction surveys;
- student surveys;
- graduate satisfaction surveys;
- student success on CSMLS certification examinations;
- student practical assessments and theoretical exams;
- comments from preceptors and clinical instructors;
- graduate employment uptake statistics.

Upon further inquiry, it became apparent that these evaluation strategies are fairly general in nature. In almost all cases, they inquire into satisfaction or student performance as a whole, and cannot offer any insight into the impact of simulations in particular on student outcomes. No participants reported on research comparing the effectiveness of traditional and simulated learning activities.

The comments of study participants provide narrative evaluations that speak to the overall success of simulations.

Simulation instructors

Although there were comments about initial skepticism among educators about simulation laboratories, instructors who teach in simulated laboratories regard the learning experiences as mainly beneficial. They feel that simulations are valuable opportunities for instructors to offer an integrated case-based perspective as well as to identify weaknesses in students' skills and to institute remedial action. However, instructors expressed concerns about the time and energy involved, and their inabilities to adequately address student needs during the simulated laboratory session due to insufficient numbers of instructional staff.

Survey participants reflected that, based on their experiences with simulated laboratories, they would like to see more resources provided for implementing the experiences, including

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[8] Herbst, D. H., Morris, S., Fort, J., Schneider, L., Veitenheimer, K., & Deane, S. (2006). Identifying best practices for clinical practice education. Ottawa: Health Canada.
[9] Chamberlin, S. (2007). Simulations in medical laboratory education: Voices of experience. A panel presentation at the Leadership Forum of the Canadian Society for Medical Laboratory Science, Hamilton Ontario, May 2007.

instrumentation, staff, budget, and time. They also felt that it would be valuable to introduce opportunities for interprofessional interactions. Some respondents expressed a wish for more time for simulated laboratories, while others felt that there should be less simulation and more time spent in the clinical environment.

Instructors report a great deal of pleasure at seeing students benefiting from simulation-based activities. They say that students enjoy the hands-on practical application in the simulation labs of what they've learned, although students apparently admit to instructors that they'd rather be in a real laboratory than a simulation.

> ***Students really want to be in the lab.*** (Simulations instructor)

Students tell instructors that they are surprised at the intensity of the work, and that they find the block simulation laboratories 'brutal', 'demanding', intense, and stressful. They are particularly conscious of the pressures created by instrument malfunctions. However, students apparently acknowledge the good preparation that simulation labs afford them. Simulation instructors hear from students that they (students) didn't realize how things in the laboratory interact; they appreciate following specimens from beginning to end and seeing the teamwork of the department. Instructors reported that students are fairly positive about their experiences in simulated laboratories, although one instructor noted that students have difficulty viewing the simulated laboratories as 'real' or appreciating the potential safety hazards.

> ***In the college setting, students don't believe that what they're working with is dangerous.***
>
> ***Students have difficulty thinking they [simulations] are real – especially those with lots of university. It takes 6 months to get them from thinking of tests as 'experiments'. But they do seem to appreciate learning and making mistakes here, instead of at the hospital, in front of a potential employer.***
>
> ***Students are allowed to make mistakes (but they should learn from them). MLTs are not.***

Instructors expressed a great deal of pride about the hard work involved in implementing a simulated laboratory for the first time.

> ***They said a lot of things couldn't be done that we did.***
>
> ***This job is like parenting: hard work but worth it. We can't believe how much time we put in, arriving at 6 or 7 every morning, giving blood, cleaning up after the students left. Marking happened after that.***
>
> ***Knowing that the students were counting on us to do this was a powerful motivator. There was constant revamping and adjusting … lots of little things to think of. In a hospital, it's [laboratory supplies] all there. Here, it all had to be***

planned for. Knowing there was an end to it was the only thing that kept us going.

This is the hardest work I've ever done.

It takes a lot of time and energy, but we are happy with the product. …It takes a few years to get used to but it is so worth it! It keeps you, as an instructor, in touch with what you are teaching. It keeps you feeling part of our profession.

Instructors stress how important certain skills are for those who supervise simulation laboratories: they name experience, flexibility, technical know-how, and awareness of the current workplace as key characteristics. They maintain that it is essential to be current in order to create a relevant learning experience for students, and note that cross-disciplinary expertise is a definite advantage (to serve as a knowledgeable backup or second in labs outside of main area of expertise). Two instructors in programs with block simulations expressed a desire for a more integrated program model, and envied the one Canadian program that is located right in the clinical site. They were unanimous in their desire for more financial support for simulations to permit appropriate, sustainable staffing, space allocation and resources. Simulation instructors would like to make the day longer (to match a work day) so that students aren't rushed and to permit debriefing at the end of the day.

Students and recent graduates

In this discussion, 'students' refers to both current students and recent graduates of the programs visited.

Students express a high level of satisfaction with simulated laboratories and appreciate being able to make mistakes there rather than in a real hospital in front of a potential employer. They find the simulated experience to be good preparation for the real laboratory world and value the consistency of this learning environment. They felt that their simulation laboratories provided a good transition into the workplace and had been an essential part of their preparation for their clinical placements:

[In simulations] you're learning the basics without pressure. You get instant feedback from instructors. You know where you're at and you're able to improve.

I can't imagine going into the clinical placement without a simulation first. I would have felt lost. It's already hard enough to get used to. You need to be really prepared.

Students in the 'integrated' model appreciated the value of a simulation that immediately preceded their placement in the clinical environment.

The stuff we were learning, I knew I'd be using right away.

Students stressed the need for relevance in their simulation laboratories: they want up-to-date instrumentation and methods, instruments that work when they're supposed to, instructors who are knowledgeable about the current workplace environment; and direct applicability of what they learn to their clinical placement.

> ***Teachers don't know what the real world is like. They should have to go back.***
>
> ***The equipment at the school is old and irrelevant. …We spend too much time at the school fixing machines. … The technology is easier here [in the clinical site]. It works.***
>
> ***The 'most recently out' [of the workplace] teachers offer better preparation.***
>
> ***We don't want to do 'make work' activities. The repetitiveness was frustrating.***

Nonetheless they recognized the pressures of limited resources.

> ***All in all, the college did a pretty good job.***
>
> ***The program is doing the best it can with what it has.***

Students appreciated the differing skills that simulation instructors offer when compared to clinical instructors or bench technologists. They also reported being afraid of slowing down the bench technologist or keeping them from their work. They recognized that bench technologists are often so busy with their workload that their students get put on the 'back burner' and sit around feeling unproductive.

> ***The college instructors are teachers; bench techs may not know how to teach. Bench techs can't always answer questions. They know the technology best.***
>
> ***The instructors are here for you. They can stop everything to teach something. You can't do that in the laboratory.***
>
> ***Simulations are a good opportunity to increase your theory. You won't do that on the bench in the lab. They expect you to know your theory. The techs are more patient if you know your theory. They don't get irritated. It doesn't hold them back. [Simulation] is a good chance to integrate theory with practice.***
>
> ***Early student labs teach the 'perfect way'. Simulations teach the efficient way so you're able to handle the workload in the clinical placement.***

Students reported that their transition into the clinical environment is 'nerve-wracking', 'intense', 'terrifying' and 'overwhelming'. They were surprised at the intrusiveness of telephone calls, and the numbers of interruptions to work. As a result, they appreciated the preparation that simulation laboratories offered them. Students recognized the confidence-enhancing nature of simulation laboratories. They saw simulations as serving a complementary function with clinical placements and as having both review and transitional functions. Students appreciated that simulations set out clear expectations for their clinical placements and felt prepared for the responsibilities of the workplace and for taking charge of their own learning.

> ***I'm very proud of myself.***
>
> ***It was good to realize that what we're doing is working!***
>
> ***Simulations provide a safer place to screw up.***
>
> ***It's more real than school.***
>
> ***When I got to the lab, I felt I could say to the bench tech "I'll come looking for you if I have a question" or "I'll figure it out on my own".***
>
> ***I usually know when I'm ready. I would have felt less confident without the simulations.***

Students enjoyed the role-play of simulated laboratories but reflected that they were always aware that the environment was not 'real'.

> ***It was really fun. They [instructors] acted like real doctors and nurses!***
>
> ***The setup is not like real life because of the space constraints. … It is a make-do setup.***
>
> ***In the back of your mind, you know it's not real.***
>
> ***It's very different from a real lab. We have to handle situations that never happened in the simulation lab. Anything can happen in a real lab.***
>
> ***I didn't feel like a real worker. I felt like a student in that closed-off room.***
>
> ***I just didn't feel I should invest much in learning a system when I knew it wouldn't be used in the real environment.***

Students appreciated the teamwork necessitated by simulation lab setups. They recognized the valuable skills learned for building professional relationships, learning to trust others, and getting along with their colleagues. They liked working in groups and learning from each other.

> ***Other students can tell me in a way I can understand.***
>
> ***It was nice to have others there, and learning to work around each other. I had a changed perception of myself upon moving into the lab.***
>
> ***It's lonely on a bench with a tech you don't know.***
>
> ***It was a good opportunity for students to be students.***

Students in programs with relatively short clinical placements felt quite strongly that they needed more time in a clinical placement.

> ***It would be awesome to have a longer clinical placement.***
>
> ***We need more time in an actual lab. You can't practice some things, like chemistry, for very long. You need to get into the real lab.***
>
> ***Clinical placement is more important than simulations. You work with the real instruments and get real exposure to work flow.***

Students worried that time spent in simulation laboratories would not be appreciated by employers.

> ***Will simulations prevent me from getting a job?***

Internationally-educated technologists were particularly appreciative of the opportunities that simulation laboratories afforded them and of the work of their instructors. For these individuals, the simulations may offer their first opportunity to become familiarized with the Canadian health care environment. Several commented that, in their country of origin, technologists were not even allowed to work with instruments; this was reserved for the pathologists or clinical scientists. They reported being initially afraid to even touch the simulation lab instruments but found the simulations a good way to build their confidence, especially if they had been out of the workplace for some time. Nonetheless, once these individuals completed their programs and sought employment in the workplace, they felt somewhat disadvantaged, as employers did not recognize their prior work experience or their time in a simulation lab. They were unhappy that simulation-based learning was not credible for employment purposes.

> ***They [employers] should realize that we are not inferior to these people [Canadian graduates of full-time programs]. We have more experience than 'fresh' students. They have only hospital training. Still we have to prove ourselves.***
>
> ***I would have liked one or two months in the hospital setting. The simulations were not enough. Time in the hospital setting would familiarize us. It would allow employers to get to know us and realize that they can trust us.***
>
> ***Nobody trusted me when I was looking for a job. They didn't trust that the simulation lab gave me enough experience to take a real job.***

Admittedly, there is no way to know if the simulation backgrounds of these individuals were the only reason for the challenges they encountered in finding employment, since other factors have also been implicated in the difficulties experienced by internationally-educated medical laboratory technologists in the workplace.[10]

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[10] Haley, B. & Simosko, S. (2006). Prior learning assessment and internationally trained medical laboratory technologists. Ottawa: Canadian Association for Prior Learning Assessment.

According to students, simulation laboratories are good for building basic technical skills and some soft skills, and for reinforcing theory. Students acknowledged that there were some things the simulations did not prepare them for: the chaos and intensity, the interconnectedness of various parts of the laboratory, and the political issues of the laboratory (for example, one student reported being upset at the poor treatment of laboratory assistants by medical laboratory technologists).

Students would like to see more automation and computers – not having been adequately prepared for the technology of the clinical environment was seen as a huge gap and a source of a great deal of anxiety once students entered the clinical environment. Some appreciated the theoretical foundations afforded by performing tried-and-true manual methods, while others felt it was wasted time. Some students disliked the overwhelming nature of simulations; they found them disorganized and too fast-paced.

Clinical educators and laboratory administrators

Because they are less involved and generally removed from the simulation laboratories themselves, clinical partners felt less able to comment on simulations. However, they did express a wish that students came to them with more developed skills with automation and laboratory information systems. In addition, one clinical instructor felt that simulations alone were particularly inadequate for internationally-educated medical laboratory technologists; she reported that one such individual required twice the orientation to the workplace that a new graduate from a full-time program would have needed.

Clinical instructors were alert to the distress that many of their students experienced on encountering the pressures of the clinical environment for the first time and speculated on how to prepare students better. Several clinical instructors suggested that simulation instructors should facilitate a simulated 'disaster day', in which the students could experience one day of high-pressure, high stakes laboratory work: some of the features they proposed for this activity included instituting a mock laboratory lock-down or quarantine; providing large volumes of specimens; engaging medical laboratory technologists and other health professionals from the work environment to do role play; and inviting first-year or high school students to observe as a professional familiarization exercise.

Most clinical partners were satisfied with the quality of student that they were receiving from the educational institution. They had few concerns about simulations and more about the workload, responsibility, and lack of recognition associated with having students for clinical placements. They felt that they just didn't have the time or financial resources to fully support clinical placements and that it was up to academic institutions to give students a good grounding in theory and techniques first. These concerns were discussed thoroughly in a previous study.[11]

One group of clinical instructors agreed that, if simulations can better prepare students for their clinical placement, they are a good thing. However, they, more than any other group, were adamant that simulations cannot offer the valuable learning experience of clinical placements and cannot replace time in the clinical setting.

[11] Grant, M. M. & Davis, K. H. (2004). Cited previously.

In discussing the expectations for preparedness of students coming into the laboratory environment, one laboratory manager acknowledged that students always face challenges learning LIS and other automated systems. Her comments echoed those of other respondents from the clinical environment about the role of authentic clinical experience in the education of medical laboratory students:

> ***It doesn't matter which school they're from, it's experience they lack. …There's always something new, always something to learn. …Until you're in the middle of it and being pulled in three directions – that's the only way you're going to learn. …Students need to be in the experience to learn about how to prioritize. Simulation helps, but it's not the same as the real thing. Some things you can only learn as you go along.***

The relationship between simulations and clinical placements

Study participants' comments created a clear picture of the relationship between simulations and clinical placements. Simulations function as a transition to the work environment; phrases used included 'a bridge between didactic and the bench', a 'tune-up', 'ramping students up', and preparing students to 'hit the road running' once they begin their clinical placement.

Simulations complement clinical placements but cannot replace them. A number of study participants saw simulations as 'second best'. They felt that simulations produce less prepared students than a comparable time in a clinical environment, and that shortening clinical placements produced a clear decline in the confidence and quality of students' skills. One clinical instructor felt that students became productive faster once they moved into the clinical environment. Students who experienced employer doubts about the value of their simulation experiences were left with the feeling that they were distinctly disadvantaged without a clinical placement in their educational program. Clinical placement appears to count as Canadian work experience in employers' estimations, but simulation laboratories do not.

Since simulations are being proposed as a means to decrease the length of time that students spend in their clinical placements, it would be useful to determine an optimum balance between the two. However, interview participants were divided on the right amount of time for either. Some want more simulation, and others want more or less time in the clinical environment; no-one advocated an 'ideal' amount of time. One clinical instructor felt that students would be bored if they had to spend more time in the clinical laboratory during their placement. Interestingly, despite their concerns about the pressures of training students, a number of clinical educators want to train students longer: they felt that students need more time on instrumentation and time for remediation and review. Longer clinical training periods allow employers and technologists more time to assess the student as a potential future employee. Clinical instructors also acknowledged that students become more productive the longer they train in the laboratory; keeping students longer in the clinical setting allows them to contribute more to actual laboratory workload. However, academic instructors expressed concerns about the potential exploitation that might occur if students are viewed as a means to address a laboratory's work overload and staffing deficits. Nonetheless, despite the enjoyment that many clinical instructors describe about training students, there is a clear expectation that students must not interfere with laboratory productivity. Ensuring that students' skills are up to the task is felt to be a major goal of the educational programs in general and of simulation laboratories in particular.

With respect to understanding the relationship between simulations and clinical placements, one simulation instructor offered an interesting re-conceptualization: instead of describing simulations as meeting whatever needs could not be met by clinical placements, he described clinical placements as being used to "introduce the students to activities that could not be simulated."[12] Clinical placements were thus re-positioned as adjuncts to simulated laboratories, rather than the commonly-held reverse notion.

A final perspective on the relationship between simulations and clinical placements considers their physical proximity. Simulation and clinical instructors in the one integrated program that shares physical space for its simulated laboratories noted distinct advantages to the arrangement, including ongoing student exposure to the clinical environment and the facilitated collaboration between the two groups of instructors. In fact, the instructors in this program do not actually refer to their simulation laboratories as 'simulations', since the students carry out their review and practice activities within an authentic clinical setting. For them, the simulations are actually an extension of the clinical placement. According to many of the study participants, simulations are easier, cheaper, and more effective when they take place in the clinical environment itself.

Simulations in other health professions or in the US medical laboratory profession

As indicated in the literature, the Canadian medical and nursing professions have embraced simulation-based learning, as have paramedics. The Canadian Society of Respiratory Therapists has specifically addressed simulated learning activities in its national competency profile[13] and medical radiation technologists are also making use of simulators for some of their procedures.[14] Use of simulation exercises appear in program calendars and descriptors for a number of health professional programs across the country. There does not appear to be a great deal of research about use of simulations in Canada, and The Canadian Association of Allied Health Professions has acknowledged the need to inquire into the definition and efficacy of simulations in its members' educational programs.[15]

In an attempt to seek international commentary on the use of simulations in medical laboratory science programs, the principal investigator sent a query message to MEDLAB-L, an online discussion forum of almost 3,000 laboratory practitioners around the world. The hope was to obtain information about use of simulations in programs in the United States and other countries.

[12] Keeping, D. (2007). Simulations in medical laboratory education: Voices of experience. A panel presentation at the Leadership Forum of the Canadian Society for Medical Laboratory Science, Hamilton Ontario, May 2007.
[13] Canadian Society of Respiratory Therapists. (2004). National competency profile. Ottawa: CSRT.
[14] Canadian Association of Medical Radiation Technologists. (2007). Professional development: Quick self study modules. [Online]. Available: http://www.camrt.ca/english/professional/self_study.asp September 17 2007.
[15] Canadian Association of Allied Health Programs. (2005). Minutes of the annual meeting, Moncton New Brunswick, June 2005. [Online]. Available: www.accc.ca/ftp/events/2005caahp/CAAHP_2005.pdf September 17 2007.

The single response received from a MEDLAB-L subscriber came from a laboratorian in France who referred to shareware for simulation of quality control data monitoring.[16]

Ferris State University in Michigan offers its medical laboratory students 12 hours of simulated laboratory exercises a week during their final semester; students perform laboratory tests and work with instrumentation and LIS. The clinical placement has been shortened significantly as a result of the addition of simulations to the curriculum, and the program coordinator reports good outcomes.[17]

[16] Personal communication, Philippe Marquis, Metz, France, September 20 2007. www.multiqc.com
[17] Personal communication, Barbara Ross, Ferris State University, MI, September 28 2007.

IMPLICATIONS

The issues uncovered during this project's survey and interview-based inquiries are similar to those identified in the literature. Sustainability and the need for evidence-based educational practices in simulation-based learning appear repeatedly as themes throughout this study.

The issue of sustainability relates to funding and provision of sufficient resources and instructional staff for simulation laboratories. It is apparent that simulation laboratories are demanding undertakings. Medical laboratory science programs are already the most expensive program in many educational institutions. Simulations only increase the costs further. Medical laboratory programs are currently stymied in their attempts to increase class sizes because there is no funding being directed to the clinical sites to help them support clinical education to a greater extent, or even at their current levels. They are under pressure to minimize their dependence on clinical resources; simulations are one option they are pursuing, and this strategy may be effective if a simulation-based curriculum permits larger class sizes or the dual student intake described earlier. However, programs need to be appropriately funded to do so. Short-term targeted funding with no guarantee for ongoing funding to sustain a simulation-based program constitutes a waste of money and expertise if the program must be abandoned. In fact, the curtailment of simulation-based programs and the failure to implement already-developed simulation-based curricula constitute an unexpected reverse momentum in medical laboratory education. Despite the attention being given to simulations and the potential health human resources benefits that are being ascribed to them, simulation-based learning is actually in decline in this profession due to lack of ongoing funding.

The gradual shift over time of medical laboratory education from one sector (health care) into another (education) has implications for funding, as the essentially 'invisible' costs associated with clinical education in the workplace are now becoming explicit in educational institutions' attempts to re-create the clinical environment in their simulation laboratories. This prompts a question about the duplication of resources involved in re-creating a hospital laboratory environment in an educational institution. It appears that simulations can definitely play a constructive role in medical laboratory education, but given the restraints posed by funding, technology, and other resources, might it be far more cost-effective and pedagogically-grounded to provide more support to clinical sites for facilitating the clinical education that experienced educators and students regard as the 'first choice' for learning about medical laboratory practice?

Additionally, considering the difficulties that some medical laboratory programs are experiencing in acquiring funding for their simulation laboratories, is there a risk of creating 'have' and 'have not' programs? If it should be established that simulations offer a superior learning experience, this places programs that cannot afford to offer simulations in a disadvantageous position.

It is worth asking how effectively the costs of simulations can be rationalized given the relatively sparse research supporting the use of simulations in medical laboratory education. The implementation of simulation laboratories in medical laboratory education appears to have followed the implement-first-validate-later model evident in the medical literature about simulations. There is no evidence base for determining the length of time (in simulation laboratories or clinical placements) or the learning environment that is needed to produce a medically laboratory graduate who is sufficiently competent to enter the workforce. Given the centralizing tendencies in evidence for lengths of clinical placements, it might seem that the medical laboratory education industry itself is establishing a default length for clinical placements. An earlier study suggested an average length of 25 to 30 weeks;[18] one program that, at the time of the 2004 study, had a clinical placement of 36 weeks has recently announced a curriculum change to 15 weeks of simulation and 22 weeks of clinical placement. Another program has announced that it is dropping its program's simulation laboratories and moving from 12 weeks of clinical placement to 22 weeks. It is important to stress, though, that there is no research to establish that an average of 25 weeks for clinical placements is the right amount of time; this is simply a length of time that has been determined to be tolerable given pressures on educational institutions and hospitals to work with increasingly limited resources and expanding professional, regulatory, and workplace expectations. Nor is there any indication of an optimum length for simulation laboratories, although there are assumptions that using simulation laboratories permits decreasing time spent in clinical placement. Despite any evidence base for the use of simulation laboratories, their use (or cessation) appears to figure into decisions about clinical placements.

Do simulation laboratories fully address the issues of student safety raised peripherally in this report? Patient safety may not be a driving factor in implementing simulations in medical laboratory education but the immersive and extended exposure of students and instructors to biohazards in simulation laboratories (particularly where supervision is inadequate) did not appear to generate the concern it merits.

It is also unclear whether the use of simulations will actually help to address health human resources shortages. If simulations are to succeed as a strategy for increasing class size or doubling student intake, the medical laboratory programs must be financially supported to carry through on this promise. Interestingly, employers seem to be regarding medical laboratory programs differently now that they are experiencing difficulties hiring technologists. Whereas they once regarded programs as somewhat parasitic (a metaphor suggested by one study participant), drawing excessively on their resources to train students, employers now are more interested in attracting students; they may be amenable to a more symbiotic type of relationship. Educational institutions may be able to capitalize on their new attractiveness to employers by encouraging their support for clinical placements.

Simulations may offer an opportunity to bring students closer to the culture of the health care system and to foster their development as a medical laboratory technologist, rather than as a student. They may also provide an impetus for improved collaboration between academic and clinical settings. Simulations could be interpreted as a natural progression of a historical trend. The shift of academic portions of health professions programs out of the hospital settings in the 1960s and 1970s set the stage for a noticeable divide between the theory and practice of medical laboratory science; the 'two solitudes' continue to function in many programs as two different worlds. This is evident in the comments from students in this and a previous study[18] about what it is like to make the transition from their school to the laboratory setting. There appears to be

[18] Grant, M. M. & Davis, K. H. (2004). Cited previously.

some value in former hospital-based apprenticeship-oriented models in terms of the proximity and immediacy of clinical environment to which students were once exposed right from the start. Implementing simulation laboratories may necessitate that this divide be bridged to create a more seamless and more holistic learning experience for students.

There is a definite need for more inquiry into the effectiveness of simulations: do they provide a superior experience to the clinical training that they may be replacing? In the absence of research evidence, many instructors appear to be feeling their way through the challenges of simulations, instinctively coming to decisions that are supported in the literature (for example, the importance of debriefing). This speaks well for their courage, expertise and experience. But it is important to at least question the validity of a significant pedagogical shift such as this when it is driven mainly by economic concerns. For example, while simulation instructors acknowledge that it is more cost-effective to focus on manual and semi-automated techniques in simulation laboratories, this does not meet the expressed needs of students and clinical partners and there is no evidence to support this choice aside from the bottom line. And when it comes time for educational institutions to rationalize their funding requests for simulations projects, they are at a loss because there is no research to support their claims.

Also worth questioning is the meaning of the learning acquired during a simulation where fear of academic failure, rather than altruistic motivations, underlie the learning experience. Does this experience risk becoming the ‘simulated learning’ alluded to in this report’s introduction? And it is important to note that much of the interest in simulations is driven by the increasingly common and largely unquestioned opinion that clinical education of medical laboratory technologists is a ‘burden’ to the health care system. What are the implications of driving the spirit of learning and inquiry out of the health care environment in order to serve economic concerns?

Educators do not raise the issue of program accreditation in their discussions of simulation. The Canadian Medical Association (CMA), which accredits medical laboratory programs through its Committee on Conjoint Accreditation, has a non-prescriptive approach to its requirements for programs, employing an outcome-focused competency-based process that relies on each profession to establish its criteria through a competency profile. The CMA expects an educational program to demonstrate that it has set up appropriate learning experiences and to supply evidence that the competency outcomes are being met (i.e., through employer, graduate, and preceptor feedback). In the cases of three health professions (paramedics, physician assistants, and ultrasound), the professional competency profile specifies the actual environment within which the competency must be met. However, in medical laboratory science, both ‘virtual’ and ‘clinical’ environments are considered to be appropriate environments for meeting the competency profile. What this means is that, as long as medical laboratory programs can demonstrate that their curriculum meets the requirements of the national competency profile, they will satisfy the criteria for CMA accreditation. There is a current discussion among health professional education programs about the need to specify that at least *some* clinical experience must be included as part of the learning experience, but this discussion has not yet been acted upon. [19]

[19] Personal communication, Margaret Dukes, CMA, September 26 2007

It is understandable that medical laboratory education does not give the impression of having a particularly clear agenda: medical laboratory programs vary in length, as do their clinical placements; instructors want more (or less) time in clinical placement; they want more simulations (or none at all); academic instructors say they are under pressure to decrease clinical placements but students and clinical instructors say they want longer clinical placements; educational programs are financially constrained to focus on manual and semi-automated procedures when students and clinical instructors feel that it is computerization and high-tech applications that are needed most; employers want to hire students and have them on site as a recruitment strategy but claim that they are not in a position to actually support clinical education. The stakeholders most closely involved in medical laboratory education have conflicting needs and priorities and appear to be working at cross purposes. Combine this with the lack of clear government accountability for health professional education and it is easy to see the foundations for recurring health professional shortages.

Is the attention being paid to simulations simply an avoidance strategy for those who do not want to confront the issue of clinical education? Simulations may not be a cure-all for the problems of the clinical environment. Clinical experience remains a critical element of health professional education. One researcher refers to it as the ‘signature pedagogy’ (a foundational and influential teaching practice) of medical laboratory education.[20] If simulations are truly to be an effective transition to the clinical environment, it is still necessary to address the ways in which simulation-based learning can complement clinical education, and *vice versa*. The lack of movement and support for these issues is frustrating to those who are witness to the current stasis in medical laboratory education.

The findings of this study have implications for educators: they suggest the value of debriefing and simulated core laboratories, the potential for ‘disaster days’ as learning tools, the potential for the simulations literature to provide validation for existing strategies, and the possibility of linking simulations to other funding initiatives (for example, interprofessional education) in order to secure financial support for simulation-based curricula.

Future research may address validation of specific simulation-based teaching strategies, comparisons of simulation and non-simulation based activities, and specific cost analyses for implementing a simulation laboratory. The literature review in this report suggested that the simulation-based learning experiences of medical laboratory students differ in distinct ways from those of physicians and nurses, whose research currently dominates the literature. It would be highly valuable for this profession to establish its own body of literature to guide its educators and policy-makers.

[20] Woeste, L. A., & Barham, B. J. (2006). The signature pedagogy of clinical laboratory science education: The professional practice experience. Laboratory Medicine, 37(10):591-2.

CONCLUSIONS

This research project has examined current literature, practices, and expertise in order to begin constructing a much-needed evidence base for simulated learning in medical laboratory science programs in Canada, to provide educators with exemplars of simulated laboratory learning, and to identify directions for further research. The construction of this evidence base is essential for decision- and policy-making about future directions for medical laboratory education.

Phase 1 of the study on simulations in medical laboratory programs has provided the foundations for an informed and relevant definition of simulated laboratory learning in the professional preparation of medical laboratory technologists. It has also highlighted a number of commonalities in implementation of these learning experiences and set the stage for Phase 2's deeper inquiry into the use and implications of simulated laboratories in medical laboratory education.

The findings of this study suggest the following about simulations in medical laboratory education:

- They can be an effective and supportive tool to enhance student transition into the clinical environment, but can not replace clinical experience;
- They are a major draw on resources (human and otherwise) and must be adequately supported both at startup and on an ongoing basis;
- They represent a significant shift in pedagogical practices and must be grounded in educational resources and research-based evidence which are not currently available to educators;
- They are a rewarding teaching and learning experience when supported with sufficient appropriate resources;
- They offer opportunities for academic and clinical educators to foster a more seamless educational experience;
- There is little evidence to support their use in medical laboratory education;
- Their implementation in medical laboratory education appears to be declining due to a lack of resources, most notably funding, and a lack of evidence base to support their use.
- They must be complemented with effective and well-supported clinical education resources and practices.

Themes of sustainability and the need for an evidence base for simulations in medical laboratory education have been evident throughout this process of inquiry. They call for increased attention to accountability for health professional education through research and policy making in education and health services.

APPENDICES

A – List of typical topics addressed in interviews

Academic and/or simulation instructors

Why is your program using simulations?
How do your simulation labs differ from the academic student labs?
What is involved in developing and preparing for simulation laboratories?
How did you decide which activities to simulate?
What are the resources you need to keep your simulation laboratories operating?
What is it like to facilitate a simulation laboratory?
Can you recommend any literature or educational resources on simulations?
Can you give us any information about the costs involved in your simulation laboratories?
What happens in a simulation laboratory on a typical day?
Could you show me the laboratory where the simulations take place?
How do you assess your students' learning in the simulation laboratory?
How do you know that the students are learning what they're supposed to be learning?
How do your students respond to being in a simulation laboratory?
What was the best/worst thing about your simulation laboratories?
Are you aware of any research or studies that have been conducted within or outside of your institution on simulation-based learning?
Do you have any plans to change the way you implement your simulations?
If you could change your simulations and money was no object, what would you do?

Students

What was it like going into simulation laboratories after your academic labs?
What happens in a simulation laboratory on a typical day?
What was it like going into the clinical setting after your simulation laboratories?
What was the best/worst thing about your simulation laboratories?
If you could change your simulations, what would you do?
Did you know that not all medical laboratory programs use simulation laboratories?

Clinical partners

What are your perspectives on simulation-based learning?
What is your experience with the simulation laboratories implemented by your students' educational program?
How would you describe the preparedness of students for their clinical placement?
If you could prepare students differently, what would you do?

Appendix
B – Consent forms for interviews (Two versions)

CSMLS
Canadian Society for Medical Laboratory Science

SCSLM
Société canadienne de science de laboratoire médical

May 15 2007

Dear Participant,

You have been invited to participate in a project being conducted by the Canadian Society for Medical Laboratory Science on the use of simulated laboratory learning activities in medical laboratory education. The project is entitled "Simulated Learning in Medical Laboratory Education: Current Perspectives and Practices". This study is funded by Health Canada and will inform educators and policy-makers on relevant issues in the educational preparation of medical laboratory technologists. The project's final report will be made available to study participants, and will be presented in professional venues such as the CSMLS national Congress, the *Canadian Journal of Medical Laboratory Science*, and stakeholder workshops and discussion groups.

We hope you will consent to a 30- to 60-minute interview with our project's principal investigator, Dr Moira Grant. Your participation will help to create a current and valid picture of the implementation and value of simulated laboratories and to provide stakeholders with a full appreciation of the resources and outcomes for these types of learning experiences.

All information gathered as part of this project's interviews will be confidential. You may withdraw from the study at any time. While we would like to audiotape your interview, you are free to decline audiotaping or to turn off the recorder at any point during your interview. Your audiotape will not be transcribed but will be consulted to ensure that your comments have been accurately noted. All tapes will be securely stored in the office of the researcher and will be destroyed after all data is analyzed. Your name will not be used in the analysis and writing of the reports or in any publications or presentations. While we may use quotes from your interview, they will never be attributed to you. Only the principal researcher will have access to the raw data.

If you have any questions or concerns about this project or your participation in it, please contact Moira Grant, Director of Research, CSMLS, 905-528-8642 ext. 35. *MoiraG@csmls.org*

CONSENT

I have read and understood the objectives of the interview process and I agree to participate. I am aware that my participation is voluntary and that I may withdraw at any time without fear of penalty. I give consent for my comments to be used in reports and publications that do not identify me or my workplace.

____________________ ____________________________ ____________

Your name Signature Date

CSMLS Canadian Society for Medical Laboratory Science — SCSLM Société canadienne de science de laboratoire médical

May 28 2007

Dear Participant,

You have been invited to participate in a project being conducted by the Canadian Society for Medical Laboratory Science on the use of simulated laboratory learning activities in medical laboratory education. The project is entitled “Simulated Learning in Medical Laboratory Education: Current Perspectives and Practices”. This study is funded by Health Canada and will inform educators and policy-makers on relevant issues in the educational preparation of medical laboratory technologists. The project’s final report will be made available to study participants, and will be presented in professional venues such as the CSMLS national Congress, the *Canadian Journal of Medical Laboratory Science,* and stakeholder workshops and discussion groups.

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I will be happy to answer any questions you may have about this project and your participation in it. The project’s final report will be submitted to Health Canada in October 2007 and will be available on the CSMLS web site early in 2008. Thank you for contributing to our inquiry.

Moira Grant
Director of Research
Canadian Society for Medical Laboratory Science
905-528-8642 ext. 35.
MoiraG@csmls.org

CSMLS
Canadian Society for Medical Laboratory Science

SCSLM
Société canadienne de science de laboratoire médical

PARTICIPANT CONSENT FORM

Simulated Learning in Medical Laboratory Education: Current Perspectives and Practices

I have read and understood the objectives of the interview process and I agree to participate. I am aware that my participation is voluntary and that I may withdraw at any time without fear of penalty. I give consent for my comments to be used in reports and publications that do not identify me or my workplace.

____________________	____________________________	____________
Your name (please print)	Signature	Date

Appendix
C – List of participants and contributors

NEWFOUNDLAND

College of the North Atlantic, St. John's NL

Robin Power, Program Coordinator,
Karen Kennedy, Dean, Health Sciences
Sheila Butler, Instructor
Janet Keeping, Instructor
Shirley Power, Instructor
Dave Keeping, Instructor
Debbie McCarthy, Instructor
Karen Clements, Lab Tech II
Christine Carter, student
Rana Ward, student
Kristen Ryan Roberts, student
Amy Ezekiel, student
Pamela Denty, student
Stephanie Corcoran, student

Department of Laboratory Medicine, Health Sciences Centre, St. John's NL

Dave Symonds, clinical instructor
Terry Gulliver, Program Director
Lynn Wade, Division Manager
Gail Norris, Division Manager
Terry Sharpe, clinical instructor
Bev Upshall, clinical instructor
Gilbert Butt, clinical instructor
Barry Dyer, clinical instructor
Bev Rowe, clinical instructor
Marg Noftle, Division Manager
Bill Hayward, clinical instructor
Michelle Hendry, clinical instructor
Jim Humby, clinical instructor
Janet Stephens, clinical instructor
Erin Bursy, clinical instructor
Carla Dawson, clinical instructor
Lorna Bradbury, clinical instructor

NEW BRUNSWICK

New Brunswick Community College, Saint John NB

Margie Clifford, Program Coordinator
Cathy Moran Robinson, Instructor
Trudy Charles-Young, Instructor
Rob Leathley, Acting Department Head
Bonny Muir, Instructor
Joy McLaughlin, Instructor
Rosalie MacDonald, Instructor
Betty Brown, Provincial Dean of Health
Marise Furness; Director, Human Resources
Aline Munroe, Academic Dean

Department of Laboratory Medicine, Saint John Regional Hospital, Saint John NB

Susan Buckley, clinical instructor
Barbara Mummery, clinical instructor
Erica Kittilsen, clinical instructor
Terry-Lynn Laurence, student
Stephanie Burnett, student
Craig LeBlanc, student
Melissa Butler, student
Kristen Arsenault, student
Marc Goddard, student
Karen Williams, student
Michael Des Roches, student
Claire Wright, clinical instructor
Ellen Cloutier, laboratory administrator

NOVA SCOTIA
Wendy Bryan, Project Manager, MLT Program, Nova Scotia Community College, Halifax NS

PRINCE EDWARD ISLAND
Brenda Maclean, Prince County Hospital, PEI

QUÉBEC
Joël Gagné, Coordonnateur, Programme TAB, Cegep de Rosemont, Montreal QC
Nathalie Lapointe, Directrice, Programme TAB, Cegep de Chicoutimi, Chicoutimi QC
Karen Gabriele, Chairperson, Medical Laboratory Program, Dawson College, Westmount QC
Marie Rousseau, Coordonnatrice, Programme TAB, Cegep de St-Jean-sur-Richelieu, St-Jean-sur-Richelieu QC
Karine Whittey, Coordonnatrice, Programme TAB, Cegep de Saint-Hyacinthe, Saint-Hyacinthe QC
Bernard Émond, Coordonnateur, Programme TAB, Cegep de Rimouski, Rimouski QC

ONTARIO

Mohawk/McMaster Institute of Health Sciences, Hamilton ON
Mary Golba-Bylhouwer, Program Coordinator
Charlotte Hell, Instructor
Gunathilaka Maddumaralalage, student
Dipti Gandhi, student
Amynilda Calupig, student
Mohammad Arif, student
Vaishali Patel, student

The Michener Institute for Applied Health Sciences, Toronto ON
Suzanne Allaire, Chair, Medical Laboratory Sciences
Ellen Moyo, Access & Options Program
Kelley Geddes, Program Coordinator, Access & Options Program
Kelly McPherson, Instructor, Access & Options Program

Sue Hemmerling, Program Coordinator, Medical Laboratory Program, Cambrian College, Sudbury ON
Jan Fox, Program Coordinator, Medical Laboratory Program, St. Lawrence College, Kingston ON
Jan Maxwell, Coordinator, MLS Program, St. Clair College of Applied Arts and Technology, Windsor ON
Margaret Dukes, Canadian Medical Association, Ottawa ON

SASKATCHEWAN
Aleatha Schoonover, Program Head, Medical Laboratory Program SIAST, Saskatoon SK

ALBERTA

Northern Alberta Institute of Technology, Edmonton AB

Heather Gray, Program Coordinator
Kim Mischuk, Instructor
Lori Roper, Instructor
Diane Poseluzny, Instructor
Cheri Burant, Instructor
Lia Green, Instructor
Melody Stewart, Administrative Assistant
Lina Giordano, Instructor
Johanna Scott, Instructor
Bonnie Goldrup, NAIT graduate
Poonam Gounder, NAIT graduate
Deviyani Panchal, NAIT graduate
Ming Xu, former NAIT student

University of Alberta Hospital, Edmonton AB

Jessi Pluim, student
Eugene Cheung, student
Gary Yung, student
Vanessa Wollan, student
Danielle Warnez, student
Kyla White, student
Rhonda Shea, student
Tonya Olson, student
Jenn Crawford, clinical instructor
Judy Bandura, clinical instructor
Maria Ackney, clinical instructor
Rosalind Lane, clinical instructor
Joan Carlson, Manager, Education

Medical Laboratory Science Program, University of Alberta

Jennifer McPhee, Program Coordinator
Chris Ward, Professor
Marion Fraser, Professor
Roberta Martindale, Professor

Keith Steinbach, Regional Educator, Lab Services, Capital Health, Edmonton AB
Ellen Klontz, Cross Cancer Institute, Edmonton AB
Pat Martin, Dynacare Kasper Medical Laboratories, Edmonton AB

Southern Alberta Institute of Technology

Kimberly Wheelans, Program Team Leader, Medical Laboratory Program
Sonja Chamberlin, SAIT

BRITISH COLUMBIA

Anne Murray, Medical Laboratory Program, British Columbia Institute of Technology, Burnaby BC
Rick Rice, Kamloops BC