BUILDING THE SCIENTIFIC MIND

LEARNING IN THE PERSPECTIVE OF COMPLEX AND LONG-TERM CHANGE

VANCOUVER, BC, CANADA

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FINAL REPORT

Prepared by

Jan Visser in collaboration with

Paul Barach, John van Breda and Yusra Laila Visser

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Learning Development Institute

Emily Carr Institute Art • Design • Media

UNESCO

Fundación Cultura de Paz

GENERAL ASPECTS

Organization

The Second Advanced International Colloquium on Building the Scientific Mind[1]—BtSM2007 for short—was held at the Emily Carr Institute of Art and Design[2] (ECIAD) in Vancouver, BC, Canada, from 28 to 31 May 2007. The colloquium took place under the auspices of the United Nations Educational, Scientific and Cultural Organization[3] (UNESCO). It was organized by the Learning Development Institute[4] (LDI) in collaboration with ECIAD and the Canadian Commission for UNESCO.[5] The colloquium was furthermore sponsored by the Fundación Cultura de Paz.[6] Seventy individuals[7] from around the world (46 % female; 20 countries; age range 10 to 85) signed up for the meeting.

Group photo of participants present at BtSM2007

Theme and focus

Science, in the broad sense of the word, has become an increasingly crucial dimension of life in the 21st century. The balance between how humans and nature influence each other has shifted so much in the direction of the former's impact on the latter that the geological epoch in which we now live has famously been called the Anthropocene by Paul Crutzen.[8] The shift from Holocene to Anthropocene is supposed to have taken place over the past two to three centuries due, particularly, to the dramatic advances in science and technology. These advances have created great benefits, but at the same time also great risks, for our species and for the planet at large. More than ever is there a need for every single human being to be able to view the world in which we live, among many other perspectives, from the vantage point of how we interact with it in the way that only science allows us to.

Yet, and, in a sense surprisingly, fewer and fewer people come prepared to meet the above challenge. The number of young people who prepare for careers in science is dwindling and those who enter the field often do so with expectations and attitudes that are different from those that motivated past generations of scientists; science and its societal importance are increasingly poorly understood by the general public; science and scientists have lost esteem in comparison with their status during the previous century; and generally people tend to appreciate the problems which humanity faces from perspectives that *exclude* rather than *include* their scientific dimension.

To address the above problem, a fundamental refocusing is required of how we deal with preparing ourselves for constructive participation in a world in which science plays the role it does.

[1] http://www.learndev.org/BtSM2007.html

[2] http://www.eciad.ca/

[3] http://www.unesco.org

[4] http://www.learndev.org

[5] http://www.unesco.ca

[6] www.fund-culturadepaz.org/

[7] http://www.learndev.org/dl/BtSM2007/BtSM2007-Community.pdf

[8] http://www.mpch-mainz.mpg.de/~air/anthropocene/

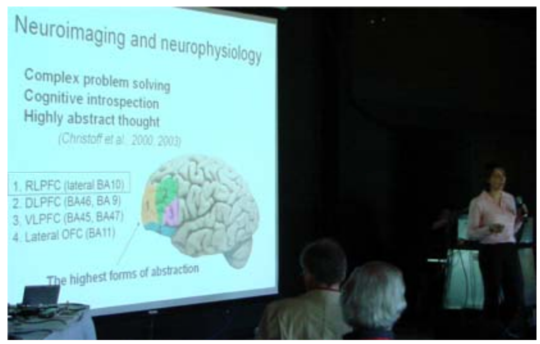
Thus, BtSM2007, like its predecessor, BtSM2005,[9] aimed at restoring the mind as a valid focus of attention in formal, non-formal and informal processes of science and technology oriented education and communication. This contrasts with the often too narrow focus on skills and factual and procedural knowledge in traditional science education. In the specific case of BtSM2007 this focus was furthermore informed by the need for humans to deal, collectively and individually, with problems that arise from human-induced change processes that are complex and have long-term consequences. Issues related to environmental impact, sustainability, and resource depletion are among the obvious examples. Edgar Morin's work on complex thinking was thus given a place of prominence in the debate.

The program

To set the tone for the above emphasis, the program[10] for the colloquium was designed to start off with a keynote by Edgar Morin during the morning of the first day. However, due to unforeseen personal circumstances, Edgar Morin was prevented from traveling to Canada and knew so only days before the start of the meeting. This led to a last minute

Panel on *Restricted and General Complexity*. Left to right: Michel Alhadeff-Jones, Dalva Padilha, Martin Gardiner, Benjamin Olshin, Paul Horwitz

decision to replace the keynote presentation by a keynote panel on *Restricted and general complexity: Reinventing the scientific mind with a view to today's problems*, largely based on a paper by Morin[11] already made available prior to the start of the colloquium*.* A large number of participants familiar with Morin's work volunteered. Half of them were collaboratively selected to serve on the panel; the other half served as respondents from the floor. Replacement of the lecture by an interactive panel provided for an active start of the four-day dialogue.



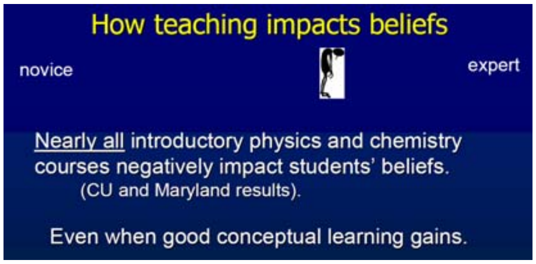
Kalina Christoff delivering her keynote on *Human Thinking: Lessons from Neuroscience*

Two more keynotes signaled additional emphases in the program. One of them, on *Human thinking: Lessons from Neuroscience*, was delivered by Kalina Christoff of the University of British Columbia and focused on recent findings about the functioning of the brain. The other keynote aimed at challenging the assumed benefits of school-based learning as regards the development of the scientific mind. Its title was *Research on how school is nurturing the anti-scientific mind and how this can be changed* and it was delivered by the 2001 Physics Nobel Laureate Carl Wieman of the University of British Columbia and the University of Colorado via video conferencing from Washington, DC. Each of the keynotes was followed by extensive in-depth discussion from the floor.

[9] http://www.learndev.org/ColloquiumBuildingTSM2005.html

[10] http://www.learndev.org/dl/BtSM2007/BtSM2007-Program.pdf

[11] http://www.learndev.org/dl/BtSM2007/EdgarMorin-FR.pdf



One of Carl Wieman's slides

Roughly half the participants presented papers or conducted workshops. Their written contributions[12] are available on the Web pages of the colloquium. Audio files of the presentations and subsequent discussions will still be added.

An important feature of the colloquium was its self-organizational nature. Participants were encouraged, both in preparation for and during the colloquium, to identify special interests they wished to work on and to organize themselves in terms of activities and working groups to attend collaboratively to the identified concerns. This led to the establishment of three specific Special Interest Groups (SIGs) on Problem-Oriented Learning, Health Education, and Transdisciplinarity, respectively, which functioned throughout the four days of the meeting, as well as a range of activities of more limited extent and requiring lesser amounts of time. The program lists them all. Work started by the SIGs during BtSM2007 is continuing beyond the actual colloquium, mainly via the Internet. Following this introduction on general aspects of the colloquium, three separate segments are presented detailing the work of each of the Special Interest Groups.

Typical example of a self-organizing activity: Workshop on *Automated muses: A semiotic & philogenetic approach* facilitated by Mara Martin and David Vogt

[12] http://www.learndev.org/BtSM2007-Papers.html

The value of the venue

The colloquium took place in the relatively quiet ambience of Granville Island against the backdrop of the skyline of downtown Vancouver

Holding the colloquium at the Emily Carr Institute of Art and Design did not fail to provide a specific flavor to the meeting. The environment of the Institute transpires an atmosphere of active engagement, innovation and creativity on the part of those who inhabit it. That same atmosphere was infectious.

The choice of Canada had also been motivated by the thought that it would attract a slightly different audience than the previous meeting, which was held in Europe. Indeed, BtSM2007 had a higher proportion of delegates from North America whereas BtSM2005 had been biased towards Western Europe. The collaboration with Emily Carr had furthermore resulted in a more prominent presence of participants from the world of the arts.

The policy of diversification will continue, BtSM2009 being planned to take pace in Egypt, favoring the Arab region, Africa, the Middle East and the Mediterranean Basin, with BtSM2011 tentatively conceived of as a Latin American event.

PROBLEM-ORIENTED LEARNING SIG

SIG Report prepared by Yusra Laila Visser,
Florida Atlantic University and Learning Development Institute

Major problems addressed by the Problem-Oriented Learning group

The Problem-Oriented Learning (PoL) special interest group emerged out of the recognition that problems play a two-fold role in the development of the scientific mind. First, the capacity to solve problems, to deal with ambiguous situations, and to respond constructively to dynamic and unpredictable situations may be considered as one of the many essential attributes of the scientific disposition. Exploring, therefore, the acquisition of skills and habits of mind in relation to problems and problem solving, is one of the necessary components for advancing the dialogue on building the scientific mind. Secondly, the special interest group emerged from the recognition that there are many ways in which the formal education context may not be positioned optimally for holistically supporting the development of the scientific disposition. In this context, the use of instructional strategies centered on complex problems and challenges is one of the ways that educators and educational researchers may be able to work within existing educational structures to support the development of elements of the scientific discipline in the formal education content. The purpose of the PoL group was therefore to foster sustained discussion and meaningful activity around the role of problems in the context of learning and the development of the scientific mind.

Building the core group

Initially, the Problem-Oriented Learning group came into being through targeted invitations that were extended to individuals whose work on themes connected to problem-oriented learning has earned them widespread recognition and respect. The group's organizer approached these individuals and solicited their involvement by presenting them with a short description of the scope of interests of the special interest group, and by asking them to commit dedicated time during the BtSM2007 meeting to targeted discussions in relation to problem-oriented learning. So as to get the process of group collaboration going well before the BtSM meeting, invitees were asked to undertake several tasks designed to set the stage for the group's discussions during the meeting. These tasks are outlined in more detail in the section below.

Invited participants represented a broad range of disciplines, including educational research, instructional science, learning psychology, science education, mathematics education, theoretical physics, teacher education, educational technology and international development. Invited participants also represented a variety of sectors, including universities, research laboratories, secondary schools, and non-profit organizations.

Participation in the PoL group working sessions was not limited to the individuals invited by the group

Working session of the PoL group

organizer/chair. On the first day of the colloquium, the group organizer gave a short formal presentation aimed at informing all colloquium attendees about the PoL group's goals and structure, and invited other interested parties to join the working sessions. This yielded considerable interest, and it is estimated that a dozen or more additional BtSM2007 participants joined all or some of the working group meetings of the Problem-Oriented Learning group.

How the group went about its work

The work of the Problem-Oriented Learning special interest group began well in advance of the actual colloquium. The group members who had been individually approached to participate in the special interest group were sent a copy of the concept paper on *The Scientific Mind in Context*[13] (J. Visser, 2000), which provides a preliminary overview of the thoughts on the nature and scope of the scientific disposition that motivate the BtSM colloquia. They also received the SIG chair's short description of the "problem-oriented learning" focus area.[14] Participants were asked to develop some initial questions that could serve as a source of inspiration not only for their own contribution to the dialogue but that could equally inspire others in the working group and in the larger BtSM community. In addition to drafting these questions, participants were asked to provide a brief rationale or elucidating statement for each of their questions. When drafting their questions, participants were encouraged to keep in mind that BtSM2007's specific focus was on "learning in the perspective of complex and long-term change."

The questions and elucidating statements were published to the PoL Web page.[15] Participants were asked to carefully review each others questions and elucidating statements prior to their participation in the colloquium. During the actual BtSM2007 event, the submitted questions were used to frame thematic discussions during the various break-out sessions of the SIG. The following topic areas were identified for further discussion during BtSM2007:

- Problem solving, psychology, and the scientific mind.
- Design considerations for problem-oriented learning in the context of the scientific mind.
- Teaching, implementation and teacher training for building the scientific mind through problem-oriented learning.
- Epistemology and disciplinary conceptions of knowledge in the context of the scientific disposition.
- Confronting limitations of problem-oriented learning in the context of building the scientific mind.

Authors of questions related to each of the thematic areas were encouraged to take leadership positions in managing the thematic discussions. The SIG chair and organizer introduced each of the thematic areas, interjected at appropriate times to keep the discussion on topic, and took notes of contributions and comments.

Results obtained

Discussion:

Below are a few of the key topics that were covered by the Problem-Oriented Learning group during its break-out meetings at BtSM2007:

- Parameters of the scientific disposition/mind
  - Problem solving as a dimension of the scientific disposition
  - Problems as mediating mechanisms for the development of the scientific mind
- How the scientific mind manifests itself in different disciplinary contexts (the need to reconcile the nature of the scientific mind as evidenced in other disciplinary areas, e.g. the social sciences, arts, etc.).

[13] http://www.learndev.org/dl/TSM-ConceptPaper.pdf

[14] http://www.learndev.org/PBL.html

[15] http://www.learndev.org/BtSM2007-POL.html

- Defining dimensions of problem oriented learning and the scientific mind:
    - o Distinction between different “brands” of problem-oriented learning (e.g., problem-based learning, project-oriented learning, etc.)
    - o Cornerstones of problem-oriented learning design, implementation and evaluation
    - o Features of effective problem-oriented learning
    - o Foundations in problem-oriented learning (content knowledge, attitudes, strategies)
- Assessment considerations for problem-oriented learning and scientific thinking.
- Teacher education, professional development, and professional practice.
- Customization of problem-oriented learning approaches as an essential step in the effective implementation of contextualized learning opportunities.
- The nature of problem-oriented learning in formal, informal, and non-formal learning settings.

Reporting back on the results of the Problem-Oriented Learning SIG

Dissemination:

The following were identified as key mechanisms for furthering the dialogue and for disseminating ideas and considerations in relation to the use of problem-oriented learning approaches for supporting the development of the scientific disposition:

- Concrete plans for publication and presentation opportunities were identified (see section *Plans for the future* below).
- A Web site structure for continued discussion[16] by special interest group members and others interested in the general thematic area was developed.
- A wiki for the Problem-Oriented Learning group[17] was created by one of the group members.

Plans for the future

The Problem-Oriented Learning working group began its first in-person meeting by focusing on what it hoped to be able to work toward in terms of concrete products and activities to follow the BtSM2007 meeting. A variety of suggestions were made, and the group decided that it would focus on the following key things in terms of its plans for the future:

i. Technology infrastructure: The development of a Web site[18] that could house a variety of different types of resources regarding problem-oriented learning, as well as affording continued discourse and resource sharing, a mechanism for eliciting questions and supporting statements from people not able to attend BtSM, and linking to web sites of interest to individuals exploring problem-oriented learning in the context of building the scientific mind. This web site is in the early stages of its development.

ii. Publication and presentation: Members of the special interest group showed significant interest in, and commitment to, using the results from the discussion at BtSM2007 to inform continued, targeted collaboration in a variety of professional venues. Specifically, the group was interested in exploring the possibility of collaborating on papers, journal articles, and presentations at professional association meetings. At this time, a subset of the Problem-Oriented Learning SIG is working on planning a panel session that will take place at the International Association for Development of the Information Society’s (IADIS) Cognition and Exploratory Learning in the Digital Age (CELDA) conference,

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[16] http://www.public-schools.net/pol/

[17] http://www.btsm.imsaresearch.org/index.php?title=PoL

[18] Available, as earlier mentioned, at http://www.public-schools.net/pol/

which will take place in Algarve, Portugal, in December 2007. In addition, two members of the Problem-Oriented Learning SIG are working on the preliminary plans for soliciting involvement in the development of a collection of scholarly contributions synthesizing the nature of the scientific mind in different disciplinary contexts, exploring the role and applications of problem-oriented learning in that context. The intention is for this collection of scholarly articles to appear in published format in either a special issue of an academic journal or as an edited book.

iii. Continued discussion: While the BtSM2007 meeting allowed for extensive discussion around topics of interest, there were a few promising topics that the special interest group was not able to discuss in as much detail as it had hoped. One of the themes that the group hoped to discuss in more detail in the future is that of the limitations of problem-oriented learning; in other words, identifying the parameters within which problem-oriented learning strategies and approaches must function in order to support the development of the scientific mind, and recognizing at which point problem-oriented learning's usefulness to nurturing the scientific mind is limited or lost. A second theme of interest for further discussion by the special interest group was the use of problem-oriented learning for the purpose of meeting education and human development needs in developing countries and with hard-to-reach audiences. Both of these two themes will be explored in asynchronous discussion by the special interest group, using the online discussion board that is connected to the PoL web site.

TRANSDISCIPLINARITY SIG

SIG Report prepared by John van Breda (coordinator), Sustainability Institute, University of Stellenbosch, South Africa, and Sue McGregor, Mount Saint Vincent University, Canada

Rationale and challenges of the group

The idea of constituting the Transdisciplinarity Special Interest Group (TD SIG) was inspired by the theme of the conference, namely '*building the scientific mind—learning in the perspective of complex and long-term change*'. This was interpreted to mean and refer to the *complexity* and *long-term consequences* of such planetary crises as climate change, poverty, energy, violence, water, health, waste etc. facing us all today. The complex nature of these crises resides in the fact that they are not only inextricably linked, but that they are indeed *planetary* crises. This means that they manifest themselves simultaneous both globally and locally. It also means that they cannot be treated as separate or individual problems. Attempts to do so run the risk of producing short-term, piecemeal 'solutions.' However, this is a risk we cannot afford to take. Failing to provide holistic, long-term solutions to these vexing questions will have far-reaching and potentially devastating consequences for our continued and peaceful existence on Earth.

The transdisciplinarity SIG in session

Finding sustainable solutions to the complex problems facing each and every person on the planet, therefore, poses a very specific challenge to the development and building of the scientific mind. To avoid the risk of un-sustainable solutions, it becomes imperative to conceive of the enterprise of building the scientific mind fundamentally as a transdisciplinary undertaking. It can be argued that the scientific mind capable of producing sustainable solutions is dependent on the emergence of a transdisciplinary synthesis that can overcome the traditional disciplinary divide – i.e. the divisions not only amongst the natural sciences themselves, but equally the divide between the natural and social sciences. Transdisciplinarity means going *beyond* the various forms of disciplinarity, including multi- and inter-disciplinarity. In search of long-term, sustainable solutions to complex problems, it means having to *cross* disciplinary boundaries and producing knowledge with emergent properties—i.e. providing ways and means of knowing and understanding the complexity of the problems facing us which are qualitatively *different* to what is already known from the various disciplinary perspectives.

In other words, if the complex problems confronting us today require a mindset that not only recognizes their complexity, but which is also willing to accept that complexity is a key feature of the solution rationale of these complex problems, it implies that the undertaking of building the scientific mind cannot happen in the prevailing mono-disciplinary academic and intellectual environment only. To do so, could mean two things. Firstly, repeating our fragmented thinking incapable of grasping the full complexity of the planetary crises facing us and, secondly, running the risk of producing 'solutions' which perpetuate the very problems we are trying to solve. Therefore, from this perspective of looking for sustainable solutions to complex problems, building the scientific mind should be seen fundamentally as a transdisciplinary exercise.

By purporting to transcend disciplinary boundaries, transdisciplinarity not only recognizes the complexity of the situation we are facing, but it also wishes to provide the intellectual and academic environment capable of dealing with this complexity. This means creating conditions, programs and institutions conducive to transdisciplinary dialogue. However, the question does arise as to whether it is at all possible to conceive of the different disciplines on either side of the disciplinary divide finding each other, as it were, on the 'other side' of their existing boundaries? Given the disciplinary divide, is it indeed possible to imagine the different disciplines crossing their borders and developing common ways and means of understanding the complexity of the problems facing us? In short, is a transdisciplinary hermeneutics per se possible? Although these are vexing theoretical questions, the practical consequences of the way in which we respond to and answer them are indeed far-reaching. Should it be impossible to imagine the prospect of such a transdisciplinary hermeneutics it would imply that the best we could hope for is to look for 'solutions' from the different perspectives provided by the different versions of forms of disciplinarity only. And this, in turn, as we have already submitted, in all probability means coming up with non-sustainable, short-term and piecemeal solutions. Conversely, should it be feasible to conceive of the emergence of a transdisciplinary hermeneutics capable of generating convergent ways of understanding the complexity confronting us, it means embarking upon the journey of looking for those opportunities which will be creating the conditions conducive to a truly transdisciplinary dialogue. For it is only *within* such transdisciplinary dialogue that we are most likely to discover long-term, sustainable solutions.

It was, then, against this background of questions and challenges that the constituting of the TD SIG during BtSM2007 Conference was approached. It was seen as an opportunity of creating transdisciplinary dialogue. In other words, an opportunity of bringing together people from a wide range of disciplinary backgrounds over four days in Vancouver to explore the possibility of arriving at some common understanding of the problems facing us. As things emerged, and explained in more detail below, this discussion went beyond the group's self-understanding of what 'transdisciplinarity' means and started to focus on the pros and cons of establishing a transdisciplinary PhD program as a concrete response to the need for introducing and institutionalizing transdisciplinary research and studies in our predominantly mono-disciplinary academic environment across the world. The participants of the TD SIG had never met before, nor did they attempt to communicate or organize themselves into this particular SIG before commencing of the Colloquium. It was therefore set up purely as an exploratory exercise without a fixed agenda or defined outcomes. What did emerge, in the end, was the result of the following process of dialogue entered into by this group of voluntary participants from different parts of the world and from various disciplines.

> Disciplinarities inter, multi, and trans
> Damn we tried hard, as hard as we can
> This way or that way, inside or out
> Who knows what the hell we were talking about?
>
> Complexity we talked of; complex we were
> Emergence we lauded, from him and from her
> What bound us, mostly, were battles we've fought
> That it ain't what we do; but it is what we ought.
>
> The trans part was easy; the disciplines hurt
> To save them, to ban them, to make them inert
> Looking backwards were tears, contestation, and laughs
> Forwards inspiration we found in indigenous paths.
>
> The practical project was inspired by John,
> Whose Stellenboschian project was declared to be "on"
> The theorists are still in complete disarray
> God knows why--they consider such struggles as play.
>
> Brian Cantwell Smith
> May 31, 2007
> (Offered during concluding session of BtSM2007)

Self-organization and modus operandi of the group

The *transdisciplinary group* sessions were coordinated first by tacit and then explicit agreement that the group's changing members agreed to respect the principles of chaos, complexity and emergence and to respect all voices as necessary and legitimate. The group agreed that all ideas brought something to the table and tried not to be judgmental. It became evident that there were two prevailing understandings of transdisciplinarity, an insight that emerged on the second day. There are those who saw it as interdisciplinary work (crossing disciplinary boundaries) and there were those who saw it as transcending disciplines to include ideas outside the academy. Once it was figured out who held which posture, it was easy for the energy to flow because it became possible to understand why the initial resisting of ideas did not resonate all that well. This understanding enabled the group to foster a culture to scaffold the group's discourse.

On the second day, the discussion shifted to what organizing principle should bring a 'more' focused approach to the discussion. Some participants wanted to take a particular issue or problem (e.g., the environment) and use the transdisciplinary approach to address it—as a kind of a case study. Some wanted to continue the discussion that vacillated between questions regarding what form transdisciplinarity takes, what process is involved in transdisciplinary work, how it should be articulated, by whom and for what purpose. Others wanted to focus on what curricula and degree structures should look like if they were informed by the transdisciplinary approach. Still others were intrigued with a discussion of the principles and tenets of transdisciplinarity that should inform any related initiative. Consensus was reached in the group that an ongoing understanding of all these ideas and questions was necessary and that any answers are informed by the way the idea of transdisciplinarity was understood. It is paramount in transdisciplinary work that nothing is dismissed a priori because all ways of knowing matter and this includes experiential and other 'non-scientific' ways of knowing. Especially powerful was the agreement that transdisciplinarity has to be informed by indigenous ways of knowing and being in the world. There must be a meld of wisdom and science.

The whole dialogue came into sharp focus on the third day, when the coordinator shared his exciting news received via email confirming that Stellenbosch University in South Africa had approved the development of a Transdisciplinary PhD program in Sustainability Science and had allotted funding for this exercise. This impacted and shifted the conversation to an animated discussion of what such a degree should look like? Again, the two different understandings of transdisciplinarity morphed into being—some seeing it as linking disciplines within the academy (something that is called hybrid-transdisciplinarity in the literature) and others seeing it as linking the academy (including crossing disciplinary boundaries) with civil society, industry and government with profound implications for policy making and formulation.

Results obtained

Several ideas were put on the table, one from a 20-year transdisciplinary project in Egypt, another emerging idea from the Philippines. The group discussed whether there should be courses and who should develop and offer them. What would the formal curriculum look like? What would be the nature of the degree granted? Should the PhD be confined to crossing disciplines within the academy or should it include a marriage of the academy and other stakeholders in society? Perhaps the degree could be principle based and each human problem would be addressed with teams operating from those principles (as expressed, for example, by Edgar Morin, Manfred Max-Neef and Basarab Nicolsecu). One suggestion was that the process be driven by the nature of the problem(s) being addressed rather than the institutional structures. Others expressed concerns for trying to fit new models into existing institutional structures, and shared their experiences with trying to work outside disciplinary boundaries. All of these issues indeed made for a very lively and robust discussion. On the assumption that the intent of transdisciplinarity is to both *understand and meet the world in all its complexities*, the group agreed that, ultimately, people should work to create a university system where students are not taught within disciplinary silos. At the same time, the group acknowledged that entrenched resistance to this type of change is to be expected. In concert with changing the academy, there would have to be work on changing society's perceptions of the academy.

One suggestion for an interim strategy was to pull together disciplinary teams to work on human-environmental problems, also referred to in the literature as complex social-ecological systems. The way to pull in civil society, government and industry would be for each discipline to secure funding from its networks and pool the monies for the study of the problems. Results that are generated can be fed back to the funding agencies thereby satisfying short-term penchants for outcomes while addressing human problems and the current compartmentalized structure of the academy. Eventually, the model would emerge into a transdisciplinary approach where transdisciplinary knowledge is created and people realize that problems are better solved if all contributors are networked together.

On a larger scale, the group concurred that transdisciplinary work involves both *a theoretical project* and *a pragmatic project*. By this it was meant that there is work to be done on the theory, philosophy and methodologies (not method) of transdisciplinarity as well as work to be done on the ground with people and that *praxis* is the operating principle. Praxis in this context is to be understood as the process of anchoring theoretical knowledge into daily use for the common good of *both* humankind and nature. By way of praxis, a theory or concept (or lesson(s) being learned) becomes part of a person's or community's *lived* experience.

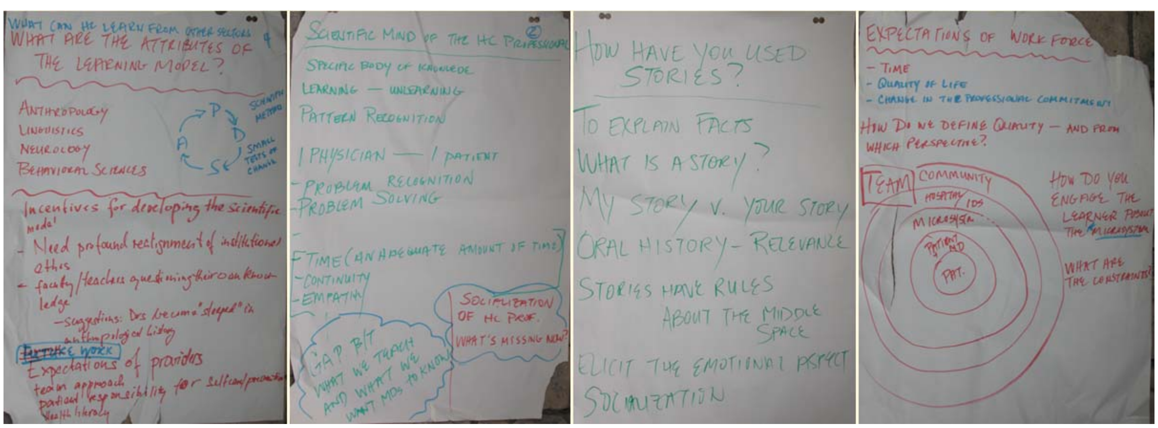
Plans for the future

In closure, the group agreed on a number of actions—some already initiated—and positions. They are listed below.

- The group will stay in touch and make the envisaged Transdisciplinary PhD program in Sustainability Science at the University of Stellenbosch (South Africa) its rallying point for now.
- The group is strongly committed to attending BtSM2009 in Egypt and report back and resume its collaborative work on that occasion
- A website and discussion forum has been set up for online collaboration at http://www.tsama.org.za
- The group will use Skype for real-time conversations.
- The group will be used as a sounding board for the evolution of the doctoral program at Stellenbosch.
- The group will contribute to an evolving shared reading list for the doctoral program.

HEALTH EDUCATION SIG

SIG Report prepared by Paul Barach,
University of Miami



Some of the 'raw' results coming out of working group sessions of the Health Education SIG during BtSM2007

Given the extent and robust nature of the summary report prepared by Paul Barach regarding the high level discussions of the Health Education SIG, we present this segment of the report as a separate but integral component of the present document in annex. The Health Education SIG chose to focus on the patient safety curriculum as an example of a concrete curriculum that could be addressed using the competencies discussed at the meeting.

Designing the Health Science Curriculum and Scientific Mind: Conclusions from the Building the Scientific Mind Roundtable Conference, Vancouver, June 2007

Abstract

Managing patients' risk for injury while they are receiving medical care is a national priority in the United States and other countries. While this has been true for at least five years - ever since the National Academy of Sciences' Institute of Medicine (IOM) reported that medical errors were the 4th to 8th largest cause of preventable death - little progress has been made.

The difficulty is that large gaps exist between what is now well agreed on and should be happening and what actually is happening. There are many signals that people working within Healthcare are losing motivation. All their early passion for their work, and compassion for people in vulnerable phases of their lives, is being drained away by bureaucracy, professional attitudes, a dominant financial focus etc. While high quality patient safety curricular materials have been produced by highly regarded organizations, no consensus currently exists about what a core curriculum for the field of patient safety should be. Further, most professional and paraprofessional medical team members currently in the work force have not been trained in safety sciences.

To craft a comprehensive, learner friendly, high quality, patient safety curriculum, the Project can build on existing curricular material identifying the skills, knowledge and behaviors/attitudes to guide patient safety education for healthcare workers at all levels within healthcare. The working group will use a high-impact education-dissemination mechanism, proven to be extremely effective, which uses a curriculum-driven approach grounded in specific adult learning methods to teach both content and how to disseminate it. Trainers could be

provided with skills in the best adult teaching methods and practices for their own settings. Using them, they will be easily able to adapt the materials to what best suits their end-learners' needs and particular organization's work culture. We might use conferences, various Web-based interactions, such as distance learning modules, blogs, and listserv announcements to foster an interactive virtual College.

Vision:

To create a retreat where experts in patient safety, quality care, simulation and health sciences education can come together in a relaxed and informal setting to review, discuss, define and help implement innovative strategies in education that support a culture of patient safety and optimal patient and community welfare.

Goals and Objectives:

The goals and objectives of the working group were to:

1. Bring together leading interdisciplinary stakeholders necessary for the development and implementation of patient safety curricula.

2. Identify and affirm appropriate educational strategies and methodologies.

3. Design, implementation and assessment of longitudinal curricula that meet these goals and objectives.

4. Identify and assess implementation barriers and strategize on how to overcome them.

Background

Educating the healthcare mind is increasingly struggling to comprehend the complexity and richness of healthcare interactions. What are the attributes of the learning model? New strategies and methods are needed to understand patient safety risks, such as faulty diagnoses, lack of knowledge transfer during patient handoffs, and issues with teamwork in high-stress, fluid, and dynamic clinical environments. Much research from braod fields including anthropology, linguistics, neurology and behavioral sciences have had a major impact on the way health care providers are taught. Several strategies have been proposed to address these risks, such as creating high-reliability teams, increasing diagnostic reliability, and improving knowledge transfer within and across clinical microsystems. Another pathway to identify and prevent patient safety risks is to harness reflection-in-action.

At one level, “reflection-in-action” is the ability to think while acting and act while thinking. Everyone has this ability and uses it everyday; few of us are aware of it, fewer still use it to improve practice, and fewer still do it as part of a workplace group, such as a caregiving team. Still fewer healthcare organizations, and systems, have parallel learning, reflection, and action methods that maintain dynamic alignment and learning across individual, team, and system levels of work.

We described current research and practice for identifying, fostering, and using this capacity as a conscious strategy to improve the ability of clinicians and care-giving teams to anticipate and address safety risks. This method allows for adjustments on-the-fly under conditions of dynamic complexity in clinical environments, and can improve the processes for physician and team performance review. We advanced three types of reflective practice research:

- Frame Analysis
- Repertoire-Building Research
- Research on fundamental methods of inquiry and overarching theories
-

Health Care Curriculum

The goal of a medical education curriculum is to prepare students to address problems that affect the health of the public.[1] We choose to focus on medical errors and patient safety as a platform to develop the scientific mind of healthcare students. Patient safety has emerged as global concern in the provision of quality health care. There has been considerable discussion in both the public and private sectors regarding ways to modify the current medical system to address the concerns raised by the Institute of Medicine's (IOM) 1999 report, entitled "To Err is Human; Building a Safer Health System."[2] The IOM's report estimated as many as 98,000 patients die every year from preventable medical errors in hospitals. In the IOM's follow-up report, "Crossing the Quality Chasm: A New Health System for the 21st Century" the IOM called for change in the education and training of physicians in order to address these problems.[3] The Association of American Medical Colleges (AAMC) has called for a "collaborative effort to ensure that the next generation of physicians is adequately prepared to recognize the sources of error in medical practice, to acknowledge their own vulnerability to error, and to engage fully in the process of continuous quality improvement (CQI)".[4] However, serious discussions on the design, implementation, assessment, and faculty development needs of patient safety education in undergraduate medical education have been sparse. Although patient safety has been increasingly recognized as a key dimension of quality care, few schools have modified their curricula to meet these concerns and little has been published in the literature addressing patient safety competencies that could be introduced at the undergraduate level.[5-6-7] Gould noted, "Few schools have attempted to give their students the skills they need to measure the outcomes of care they will provide to their patients".[8]

Identifying and implementing patient safety knowledge, skills and attitudes that are specific to undergraduate medical education is challenging. The authors invited key stakeholders from the fields of nursing, pharmacy, medicine, public health, and law, as well as senior health care administration, students, residents, and patient advocacy leaders. Content experts invited included experts in medical education, curriculum innovation, faculty development, error science, simulator science, quality care, informatics, risk management, law, and accreditation.

Stakeholders and content experts started to develop a structural framework for a patient safety curriculum through conversations and communications prior to the roundtable. The roundtable participants met for three days in June 2007 to begin a deliberative inquiry process into the design of an interdisciplinary patient safety curriculum. Roundtable activities included discussions of the current literature, development of an educational needs assessment, identification of appropriate educational methodologies, and the design of multiple patient safety curricular pilot projects.

Results of Deliberations

The BTSM roundtable discussions have to date yielded three main outcomes that need to be addressed in a new curriculum to optimize the development of the scientific mind and soul of healthcare providers.

1) Seeing health care (and health care education) through a different lens

To be successful, a patient safety curriculum will require a qualitative culture shift in the way students and educators think about health care education. Health care education, as it currently exists, is focused on an individual's performance and assessment of that performance. The educational system is also silo-based, for example, very little interprofessional or team education occurs. Education, like hospital care, is organized around specific functions; medical students learn to write prescriptions, pharmacy students learn to issue the medication, and nursing students learn to deliver it to patients. Not much attention, however, is paid to the systems needed to link all these functions, and the health care students, into a coherent, integrated, and safe system. Additionally, the recognition of the system as a source of error is generally not addressed in the training of the students. Instead, students are trained to individually meet their patients' immediate needs, while working around recurrent system problems, ambiguities, and inefficiencies over and over again, eventually with a disastrous outcome. An example of an interdisciplinary systems approach to reducing medical error may be illustrative to highlight the difference in seeing health care through this different lens, a necessary shift if a patient safety curriculum is to be successful.

The CDC cites estimates that sepsis arising from the insertion of a central line affects up to 250,000 patients a year in the United States, killing 15% or more.[9] In an individual silo-based approach to this problem, health care providers might receive additional training as to how to insert the line more safely, using simulators and other advanced technology. Beyond that, occasional sepsis arising from central line insertion might be considered an unavoidable consequence of an invasive procedure. If the health care team approached the problem from a microsystems-perspective, however, other potential solutions might be considered (Barach, Mohr, 2006): using transparent dressings to improve the visibility of the wound to caregivers;

asking a nurse to supervise every insertion of a central line, watching for lapses in sterile technique, and stopping the procedure if such a lapse is seen; avoiding femoral lines because of increased infection risk; and thoroughly investigating each and every infection as soon as it is discovered. These, and other countermeasures, have been instituted in a few hospitals already utilizing a systems perspective approach, with resulting decreases in infections by as much as 87 percent. The point, however, is that if health care professionals in these hospitals had been looking at this problem from a silo-based perspective only, these countermeasures would never have been conceived, let alone implemented.

2) Specific curriculum content for a patient safety curriculum (see Appendix A)

Roundtable participants agreed on twelve specific elements of curriculum content that they believe are essential for an effective patient safety curriculum at the undergraduate medical education level.

a) History of the medical error crisis. Students learning about the scope and history of the medical error crisis will create a need to know and a call to action on the part of these future health care professionals.

b) Error science, error management, and human factor science. An overview of how medical errors occur, how humans make mistakes, environmental factors predisposing medical errors, and principles of how to trap or eliminate the errors from health care systems will equip students to deal with these issues in their professional lives.

Table 1. Examples of Performance Shaping Factors Affecting Quality of Care

Individual Factor

Clinician knowledge, skills, and abilities

Cognitive biases
Risk preference
State of health
Fatigue (including sleep deprivation, circadian effects)
Breaks and boredom
Substance use/abuse (e.g., alcohol hangover effects)
Other Stressors
Personality factors

Task Factors

Task distribution
Task demands
Workload
Job burnout
Shift work

Team/Communication

Teamwork/team dynamics
Interpersonal communication (clinician-clinician, clinician-patient)
Interpersonal influence
Groupthink

Environment of Care

Noise
Lighting
Temperature and humidity
Motion and vibration
Physical constraints (e.g., crowding)
Distractions

Equipment/Tools

Device usability
Alarms and warnings
Automation
Maintenance and obsolescence
Protective gear

Organizational/Cultural

Production pressure

Culture of safety (vs. efficiency)

* Reprinted with permission from Barach, P., et al. (2006). Trauma team performance. In W. C. Wilson, C. M. Grande, D. B. Hoyt, (Eds.), *Trauma: Resuscitation, Anesthesia, & Critical care.* New York: Marcel Dekker, Inc.

c) Medication errors and reconciliation. Medication errors are critical for students to be educated about and proficient in, since these errors are frequent, often systems-based, and amenable to effective countermeasures if examined with a patient safety lens.

d) Interdisciplinary teamwork skills (see table 2). As discussed, these skills are critical to the success of any patient safety initiative, and are very much absent in today's undergraduate medical education curricula. Issues such as role clarity, conflict resolution, chain of command, and the rehearsal of teams to provide care in specific situations (such as acute trauma or codes) all need to be addressed (Baker D, et al, 2005).

Table 2. Challenges of Acute Care Teamwork

- Difficulties coordinating conflicting actions
- Poor communication among team members
- Failure of members to function as part of a team
- Reluctance to questions the leader or more senior team members
- Failure to prioritize task demands
- Conflicting occupational cultures
- Failure to establish and maintain clear roles and goals
- Absence of experienced team members
- Inadequate number of dedicated trauma team members
- Failure to establish and maintain consistent supportive organizational infrastructure
- Leaders without "the right stuff"

e) Communication skills. While there is communication skills training in undergraduate medical education curricula currently, particular focus on errors in communication and how these might be avoided is lacking. Patient safety communication content needs to focus on written skills such as order and prescription writing, as well as chart documentation, and oral skills such as communication between members of the health care team during tasks such as hand-offs and consults.

f) Time and stress management. The ability to manage one's time and stress, recognize when another health care team member is stressed and thus less effective, and when an entire team is dysfunctional because of stress-related complications are all well-documented in safety literature to be critical to continued optimal performance.[10]

g) Outcome measures and continuous quality improvement. How do we define quality? From patient's or care giver's perspective? What are the constraints and enablers to achieving high quality? Teaching health care education students to monitor outcome measures and to critically examine failures in the system as soon as they occur will lead to improved quality of care and reduced patient safety lapses (Vohra et al, 2007). Health care providers trained in this model will more rapidly address failures in systems, rather than continuing stop-gap workarounds which inevitably lead to an adverse outcome. Lessons from industry, in particular, Toyota, can be used in health care and health care education to this end.[11]

h) Health care microsystems. Education in this arena is important to help students see the health care system through a new lens, no longer a silo-based approach to health care. Understanding that health care professionals all work in multiple microsystems and being effective in doing so as part of a larger whole are key competencies in patient safety (Mohr, Batalden, Barach, 2004).

Table 3. Characteristics of High Performing Perioperative Microsystems

Microsystem Characteristic	Definition
1. Leadership	The role of clinical leaders is to balance setting and reaching collective goals, and to empower individual autonomy and accountability, respectful action, and reflection.
2. Organizational Support	The hospital looks for ways to support the work of the perioperative suites and helps to coordinates the hand-offs between other clinical Microsystems (i.e., PACU, ICU, etc).
3. Staff Focus	There is selective hiring of the right kind of people. The orientation process is designed to fully integrate new staff into a safety culture .
4. Education and Training	All clinical microsystems have responsibility for the ongoing education and training of staff.
5. Interdependence	The interaction of staff is characterized by trust, collaboration, willingness to help each other, appreciation of complementary roles, respect and recognition that all contribute to a shared purpose of safer and high quality patient care.
6. Patient Focus	The primary concern is to meet all patient needs — caring, listening, educating, and responding to special requests, innovating to meet patient

	needs, and smooth service flow.
7. Community Focus	The microsystem is a resource for the hospital.
8. Performance Results	Performance focuses on patient outcomes, avoidable costs, streamlining delivery, using data feedback, reducing variation and frank discussions about performance.
9. Process Improvement	An atmosphere for learning and redesign is supported by the continuous monitoring of care, use of benchmarking, and a staff that are empowered to innovate.
10. Information Technology	Information is THE connector - staff to patients, staff to staff, needs with actions to meet needs. IT facilitates effective communication and multiple formal and informal channels are used to keep everyone informed all the time.

Reprinted with permission from Barach P. et al. Safety by Design: Understanding the dynamic complexity of redesigning care around the clinical microsystem. Qual Saf Health Care 2006; 15 (Suppl 1): i10-i16 (77).

i) Risk management and root cause analysis. Risks and hazards that are embedded within the structure and process of care have the potential for causing injury and/or harm to patients. Within the process of care is the potential for active failure from individual actions of members of the health care team. "Organizational pathogens", latent conditions within both the process and structure of care – can set up the sharp-end health care providers for failure. Thus, to achieve the outcome of safe care, both the structure and processes of care must be modified before these latent conditions become active and cause unintended and avoidable patient harm. Accurate identification of the root causes of events must precede identification and implementation of appropriate interventions. Moreover, solutions for risk associated with human behavior or active failures such as skill-based failures are different embedded hazards or latent failures in organizational process and structure. The use of sophisticated risk assessment techniques including process mapping, FMEA, and PRA can be used to identify at which point interventions are most appropriate. This information is essential to give health care providers the tools to address problems in patient safety in a systematic, organized, and methodical manner, so that these problems may be reduced and/or eliminated (Apostolakis et al, 2002).

j) Full disclosure applications. Students need to be trained in the techniques of full disclosure to patients once an error has occurred. Attitudes need to be formed early in students that the admission of mistakes and the ability to say "I don't know" are valued, as these attitudes will allow the culture of medicine to shift to one of patient safety and continuous learning from mistakes, critical to their prevention in the future (Cantor, 2005).

k) Informatics, electronic medical records, and health care technology. A working knowledge of these new developments in health care will allow students to interact with them and understand their importance in the reduction of medical errors in a health care system.

3) General curricular principles in a patient safety curriculum

a.) Interprofessional education. Roundtable participants emphasized that interprofessional education should be a cornerstone of curricula for health science students and that interprofessional education should be introduced early in the educational process. Effective interprofessional teamwork is known to reduce errors caused by miscommunication and poor patient care handover.[12] Grumback and Bodenheimer concluded that research on patient care teams suggests that cohesive teams where physicians and other healthcare professionals work together are associated with improved patient outcomes.[13] Improved teamwork skills and greater collaboration between professions have been linked with safe and effective health care.[14] Students need to be aware of these outcome improvements. Additionally, students need to both understand and experience first hand the fact that "interprofessional learning consists of more than just sharing the same learning environment: it involves acquiring an understanding of the knowledge base, values and ethos of like-minded individuals and developing respect for each others contribution to the learning process".[15] We cannot expect that students educated in the current silo model of training will be able to effectively work in interprofessional teams once they have finished their training.

b.) Longitudinal curricular approach. Roundtable members believe that longitudinal approaches must be employed in patient safety education at the undergraduate level. Practicing and reinforcing safety skills at each level are key elements in effective learning. The Dreyfus educational model has been used to describe five longitudinal stages in the development of knowledge and skills of pilots.[16] Similar developmental processes have been seen in chess players, adults learning a second language, and adults learning to drive an automobile.[17] Batalden defined medical education and physician development as a continuum starting at the beginning of medical school and continuing throughout a practitioner's professional career, and argued that the Dreyfus learning model could be applied to medical education.[18] The first stage of the Dreyfus model ("novice stage") is where basic concepts, skills and values are learned. For clinical skills, Batalden noted "this is where the beginning student starts learning how to take a medical history through memorization of the chief complaint, history of present illness, review of systems and family and social history." In the second stage, known as the advanced beginner stage, students begin to experiment with limited applications. It is in this second stage that "the third year medical student begins to appreciate common situations such as those facing hospitalized patients (admissions, rounds, discharge) that can only be learned through experience. The remaining three stages continue through residency and mid-career, where the recognition of patterns and the use of intuition are the major work drivers". In similar fashion, a basic understanding of the concepts and values of patient safety should be introduced early in the curriculum, preferably in the first two years, followed by the supervised experimentation and application of these concepts during clinical clerkships and on into graduate education.

c.) Advanced patient safety educational opportunities for senior students. Roundtable participants agreed that students seeking further knowledge in patient safety should have access to more intensive educational opportunities as electives. Further training in advanced competencies could help interested students develop into leaders, researchers, and scholars in the patient safety field.

d.) Teaching methodologies. There are a number of different strategies and educational modalities that roundtable participants thought should be utilized in addressing patient safety education at the undergraduate level. These include plenaries, small group learning sessions, experiential learning, simulation, standardized patient role-plays, case-based learning, individual and team-based learning, and supportive audio-visual material. Deliberate learning is the key to effective learning and retention of patient safety information, as well as the requisite skills and attitudes (ref. Ericsson, 2002).

e.) Assessment strategies. Roundtable participants stressed that health profession students will need to be assessed in their abilities as team members, not only individually, in a successful patient safety curriculum. Their abilities to see systems-based problems and inefficiencies and to offer systemic solutions through root cause analyses will also need to be assessed. These skills are not easily acquired, but are nonetheless critical to enable optimal performance in a health care environment focused on patient safety.

Storytelling and Story Analysis: Mechanisms for Influencing the Development of the Scientific Mind of Healthcare Providers.

There is a growing interest in stories in a variety of sectors. From health care to the World Bank, people are using stories to elicit tacit knowledge, surface assumptions, and learn from experience together. People also find stories pleasurable and engaging. But the pragmatists in the audience say, “So what? Stories just make people feel good.” The presentation will help bridge the gap between insight and action, by exploring ways of using stories in the workplace to enrich decision-making, learning, and evaluation.

Stories create connection, energy, and emotional impact. They are used by teachers and mentors to engage, influence, and persuade. Stories are increasingly seen as a leveraged strategy to foster shared understanding and communities of practice in learning environments. Stories convey culture. Telling stories by the campfire, or the water cooler, or the hearth is a time-honored way to pass on culture, wisdom, and experience. Elders mentor the younger generation by telling stories; craftsmen use stories to help apprentices take on nuance, rules of thumb, and tricks of the trade.

Stories are data. They are used to frame reality, make sense of events, and detect early evidence of new and unforeseen possibilities. And they are cited as “proof” of points of view, judgments, and decisions. However, stories are also seen as “soft”, as indicators of infrequent events and the use of intuition rather than rigorous analysis and rational decision-making. In the realm of evidence, stories are referred to as “random and anecdotal.” For more valid data, the argument goes, we need numbers, frequency, appropriate sample size, and statistics.

Story Analysis (TM) is a methodology developed to address these concerns, bridge the “gap” between stories and numbers, and access the rich pool of experience contained in our stories. Story-telling is a necessary first step, since most of us do not see that “stories” and “analysis” can go together. But once we have a story with emotional resonance, we can look more closely at it and detect clues, signals, and patterns. By identifying the elements and causal relationships within a story, we can begin to distill the experience within it into “lessons learned” and rules of thumb. These can be viewed not simply as aphorisms, but also as testable hypotheses. To conduct such tests, we need to design naturalistic experiments and use the data of observation to test our hypotheses. This kind of testing can help us to identify more robust patterns, as well as the environmental conditions that support them. At this point, "story" analysis becomes "pattern" analysis, and it becomes possible to use stories to consciously design new patterns of practice, as well as environments and social systems that reinforce and support them.

In brief, we see story-telling as the gateway, or portal, to story analysis and using stories. The three steps, taken together, have powerful potential for transforming social, technical, and educational systems. They also provide a foundation, or capability, which can foster more robust approaches in several key areas, such as:

- Evaluation, measurement, and intervention;
- Learning from experience together; and
- Accelerating the learning of trainees and apprentices.

Barriers to Implementing New Curriculum

The BTSM Roundtable participants identified a number of challenges and barriers in implementing inovative an undergraduate medical education curriculum. First, many physicians and educators serving as instructors, mentors, and role models have limited knowledge and experience with the competencies required, since the current medical-legal environment favors hiding errors and near-misses instead of learning from them. Indeed, most physicians believe they provide safe patient care and do not make mistakes. In a survey given to over 1000 doctors, nurses, and residents in urban teaching and non-teaching hospitals, one-third of intensive care staff stated that they have never made an error.[19] However, only a third reported that errors are handled appropriately and over half reported that they find it difficult to discuss mistakes. Second, educational models are predominantly driven by individual, silo-based performance on examinations that preferentially reward memorization and recall of knowledge over application.

Kenneth Shine, past-president of the Institute of Medicine, concluded that medicine has failed to deliver quality care to patients, because medicine equates quality with how much an individual physician knows instead of looking at quality as how well patients are cared for.[20] Changing assessment strategies to look at interprofessional cooperation and problem solving will require new methodologies to be developed and implemented. Assessment strategies will also need to be modified to reflect the importance of patient safety education and outcomes. A recent article by Kachalia et al, on the incorporation of patient safety in board certifying exams is encouraging.[21] Third, and not inconsequential, will be the struggle to carve out the time and commitment necessary for a successful, longitudinal, patient safety curriculum into an already full curriculum.

Summary and Next Steps

The goal of a medical curriculum is to teach students is to develop the scientific mind and address problems that affect the health of the public, and patient safety is a concern in the provision of quality health care that needs to be addressed immediately. Students need to understand, appreciate, and demonstrate appropriate patient safety skills early and continuously in their professional educations. Roundtable participants met for four days each in Vancouver to discuss the curricular design of an interdisciplinary patient safety curriculum. If we are to change the current culture, many believe it is important that students begin to understand, appreciate, and demonstrate appropriate skills related to medical errors and patient safety early in their professional education. Tremendous opportunity exists to profoundly influence the scientific mind and safety culture of the healthcare delivery providers by changing the educational environment, teaching methods, and health professional curricula. While progress has been made, much more is left to be done.

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Appendix A: The Patient Safety Domain Competencies

PATIENT SAFETY DOMAINS	**Knowledge, Skills, Attitudes**
1.Theoretical Foundations	Microsystems, historical trends, chaos, complexity, competency and learning, error science
2.Behavioral Aspects of Medical Professionalism	Ethics, patient quality of life, resolution of conflict
3.Interpersonal Aspects and Issues	Communication, stress and coping
4. Human Factors and Ergonomics	Design history, error taxonomies, safety tools, decision support systems, fatigue factors, user centered design
5. Systems Analysis	Systems theory, microsystems, organizations and learning disasters, place for human error, information technology
6. Quality Improvement Learning	Pareto/flow charts, and other QI tools, best practices,
7. Injury Epidemiology	Workplace hazards, worker safety, phases of injury, medicolegal aspects

8. Medication Safety	Medication errors, Adverse and near-miss reporting, tools and website, look/sound-alikes
9. Crisis Management Tools	Communication, Team work, shared decision making, bonding tools, situational awareness, Error Disclosure
10. Simulations and Simulation Science	Micro-, macro-, debriefing, immersion levels, scripting, role playing