Department of Chemical Engineering

Construing and Implementing Systems Thinking in the Study of Process Risk Management

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Declaration

To the best of my knowledge and belief this thesis contains no material previously published by any other person except where due acknowledgment has been made.

This thesis contains no material which has been accepted for the award of any other degree or diploma in any university.

The research presented and reported in this thesis was conducted in accordance with the National Health and Medical Research Council National Statement on Ethical Conduct in Human Research (2007) – updated March 2014. The proposed research study received human research ethics approval from the Curtin University Human Research Ethics Committee (EC00262), Approval Number # SMEC-72-10.

Acknowledgments

Abstract

How can systems thinking be construed in the study of PRM situations? How can it be implemented in the study of PRM situations? And, how can an educator ascertain that students are engaging in systems thinking in the study of PRM situations?

I address these questions using a hybrid methodology that blends hermeneutics and narrative inquiry approaches. Decisions concerning methodological strategies were made as the context of the inquiry situation became increasingly clearer. In the hermeneutic-narrative mode, I pursued two inter-related lines of interpretive inquiry.

In the first line of interpretive inquiry I defined systems thinking in the context of PRM education. Systems oriented ideas from non-engineering disciplines were combined with systems oriented ideas from PRM education to develop a conceptual framework of what systems thinking entails in the study and practice of PRM.

In the second line of interpretive inquiry I defined how systems thinking can be meaningfully engaged and practiced in the classroom context. Contemporary theoretical and practical advances in educational competence development were examined to develop a practical framework of how systems thinking can be engaged through activity oriented study and practice of PRM.

I found that systems thinking can be construed as an epistemic competence or an approach to examine PRM situations *systemically*. This approach involves the exercise of two commitments: (1) Recognising, appreciating, and including multiple perspectives or viewpoints (which may be contradictory) so as to evaluate the beliefs and values that motivate them; and (2) Exercising critical self-reflexivity, social and ethical awareness when examining a PRM situation.

Next, I found that systems thinking can be implemented in an activity-oriented learning environment where students simultaneously develop and understand the ability to think systemically through the practice of the above commitments. Activities that involve the resolution of ill-structured PRM problems through group discussions, case-based teaching, reflective journaling or blogging, and concept-mapping are well suited to the practice of systems thinking in PRM.

Lastly, I found that in order to ascertain whether students are engaging in systems thinking in the study of PRM situations, an educator can focus on two aspects of its

practice. The first is the *performative* aspect and involves gathering evidence that suggests students were applying the above commitments in the activities highlighted above. This evidence can be suitably analysed and interpreted using the principles of situative and socio-constructionist learning that underpin complex competence development practices. And the second is to attend to the *transformative* aspect, and involves gathering evidence that students experienced a self-transformation in their worldviews. This evidence can be gathered from students' responses to the above range of activities, as well as interviews and focus group discussions inviting students to share their views on performative and transformative aspects of practicing to think systemically. And this evidence can be suitably analysed and interpreted using the principles of transformative learning that also underpin complex competence development.

The questions that animate this inquiry are important and needed to be addressed. Systems thinking is widely recognised within the engineering education community as a core competence for professional engineering practice. Graduate engineers are expected to be competent at it, and engineering educators are expected to be competent at formally developing it in their engineering graduates. But research and discourse on how systems thinking can be taught, learned, assessed and evaluated within specific disciplines and units has been limited. And this is particularly true for PRM education where guidance on such matters is currently unavailable. I have conducted this educational inquiry in order to make a meaningful contribution to engineering education literature in the area of systems education practices. This thesis offers a contextually relevant, well-reasoned, and holistic response to the above animating questions.

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1   Introduction

An imaginative, spirited and disciplined educational inquiry is one in which the inquirer doggedly pursues a promising idea partly because it is personally interesting, and partly because it is professionally pertinent to the educational community (Conrad & Serlin, 2011). The idea that has animated this inquiry is called *Systems Thinking*.

Colloquially described as "thinking about the bigger picture" (OECD, 2002, 2005), systems thinking requires individuals to understand and consider the wider context of their actions and decisions. The ability to think and act in this way is recognised as one of the key competences by which people can achieve and maintain success in personal, social and economic spheres in contemporary times (OECD, 2002, 2005).

More importantly, however, systems thinking is particularly vital to contemporary engineering education and professional practice. Graduate engineers are expected to be competent at it, and engineering educators are expected to be competent at formally developing this professional competence in their engineering graduates (EAustralia, 2011; IChemE, 2012).

But despite its widespread acknowledgement by the above international engineering accreditation bodies as well as the international engineering education community as a core professional engineering competence, useful and meaningful inquiries into pedagogy for promotion of systems thinking within and across various engineering disciplines have been scant (Carew & Therese, 2007; Carew et al., 2009).

I pursued my educational inquiry to address the above issue within the disciplinary context of Chemical Engineering. This thesis, an outcome of my inquiry, offers a context specific pedagogic approach to engage systems thinking in the study of Process Risk Management (PRM). In the following section I provide an account of a set of crucial moments that directed my attention toward systems thinking. The account also identifies some of the reasons that served as propellants to fuel my prolonged engagement with the idea of systems thinking.

1.1   Background and Context of Inquiry into Systems Thinking

In 2009 I began co-teaching PRM in Curtin University's Department of Chemical Engineering. PRM is a core unit for final-year chemical engineering students. The

department had undertaken a curricular reform initiative so that key professional competences could be addressed as learning outcomes in specific units.

Systems thinking was one of the competences to be addressed in PRM because the discipline and practice of PRM is inherently systems oriented. Doing it well involves having to jointly attend to a wide range of issues such as safety, health, impact and influence on environment, planning, governmental administration, financial, social and human factors (Cameron, 2005).

I, therefore, assumed that given its systems orientation, the study of PRM would naturally elicit holistic thought from students when asked to manage process risk situations.

Problem-based learning (PBL) methodology was also adopted. In it learning occurs through engagement with authentic, complex, ill-structured practical discipline based problems (Savin-Baden, 2003). It seemed a good-fit because real-life PRM situations are also characterised as being complex, ill-structured and problematic in nature (Cameron, 2005).

But that was not the only reason for adopting PBL. Growing evidence from research into PBL in engineering education suggests its effectiveness in developing students' complex problem-solving skills and professional competences (Litzinger, Lattuca, Hadgraft, & Newstetter, 2011). It is also increasingly being adopted particularly in engineering education because it appears to model the ways engineers work in practice (Prince & Felder, 2006; K. A. Smith, Sheppard, Johnson, & Johnson, 2005).

More importantly, it has been shown to be effective particularly in chemical engineering education (Felder, Woods, Stice, & Rugarcia, 2000; Rugarcia, Felder, Woods, & Stice, 2000). I, consequently, assumed that engagement and development of systems thinking by students was to be a natural consequence of the adoption and practice of PBL.

The validity of both assumptions was challenged in the course of my teaching efforts that year. I observed that students did not grasp the systemic nature of the subject they were studying. For example, when asked to describe what they perceived as risks in situations from their own every-day lives, students often focused on themselves as risk receptors while ignoring the presence of – and potential of harm to – other individuals who would be involved in those social situations, the environment and socio-economic

contextual issues. In general, it seemed that the relationship of safety and risk with self, others and the environment was not readily apparent to the students.

Students also appeared predisposed to apply PRM techniques in certain situations without adequately taking into consideration contextual conditions. For example, when given a scenario involving the installation (or operation) of a specific industrial process and then being asked to identify relevant and related safety management issues and remedial strategies, the students' patterns of responses revealed that crucial strategies such as conforming with legal and regulatory frameworks, applying standards and codes, safety training and staff education, risk communication, and recognition of ethical, social and environmental responsibility were rarely mentioned.

I recognised that although the students in general were actively engaged in the study of PRM, the systems orientation of PRM was not being grasped. My feedback sessions with students emphasized the systems oriented nature of the scenarios given to them and suggested a way of thinking that was a systemic resolution for such scenarios.

Yet students reported that they perceived no difference between systems thinking and the thinking they would routinely do when asked to problem-solve. The students did not feel that they were doing systems thinking or that we were teaching them to do so.

This formative classroom teaching experience stimulated my interest in how systems thinking could be taught better. I was surprised and perplexed that many students felt that systems thinking was identical to what they perceived as engineering problem-solving, a skill they felt had been developed and applied routinely throughout their four years of engineering study. But it was equally clear to me that their notion of systems thinking failed to take contexts, interrelationships and interactions into account when problem-solving.

I turned to literature on educational competence development practices in order to better understand why my students thought and responded as they did. The venture exposed me to the inherent complexity of formal educational competence development. It also convinced me that the issue of how to embed and engage systems thinking in PRM was significantly in need of being thoughtfully investigated. What was at first a matter of personal curiosity, quickly took on a sense of professional urgency.

In general there has been inadequate research into pedagogy for promotion of discipline specific engineering competences (Borrego & Bernhard, 2011; Litzinger, et al., 2011; van

Hattum-Janssen & Mesquita, 2011). van Hattum-Janssen and Mesquita (2011) contend that although there is broad recognition about the necessity of developing competences, educational research literature is less clear on how to develop them. This proves to be true, particularly in the case of systems thinking. Engineering education research literature provides rich descriptions about it but discourse is particularly sparse on practical pedagogic concerns in specific disciplinary contexts (Carew, et al., 2009; Cattano, Nikou, & Klotz, 2011; Fordyce, 1988; Kellam, Maher, & Peters, 2008; Nehdi & Rehan, 2007).

It has been highlighted that useful and meaningful research into pedagogy for promotion of systems thinking within and across engineering disciplines has been scant and that greater research and discourse on the development of systems thinking in engineering education is necessary (Carew, et al., 2009).

The issue is genuinely problematic. The literature on systems thinking is definitive in its assertion that systems thinking means different things to different people from different backgrounds. Different disciplines have reinterpreted and applied systems ideas often in contradictory ways (Barton, Emery, Flood, Selsky, & Wolstenholme, 2004; Flood, 1999; Jackson, 1991; Midgley, 2003; Ramage & Shipp, 2009).

Over the course of a century the systems idea has flourished and evolved simultaneously in such wide ranging disciplines as engineering, operations research, organisational development, management sciences, social planning and interventions, cybernetics, ecological and environmental management, policy making, education, psychology and psychotherapy.

In keeping with this development, within engineering education, systems thinking is seen as a "meta-attribute", in that it is a valuable competence for engineering as well as non-engineering disciplines (Hadgraft, Carew, Therese, & Blundell, 2008, p. 43). As Hadgraft et al. (2008) observe, it is now recognised that the kind of awareness that underpins systems thinking coheres closely with the kind of awareness that underpins other crucial professional attributes like reflective practice, lifelong learning, innovation, creativity, openness and a sense of social justice.

Consequently, within the engineering education community there is growing awareness that while systems thinking is conceptually fuzzy and difficult to define explicitly, there is a strong sense of urgency in conceptualising it adequately in disciplinary terms if it is to

be effectively developed as a key meta-attribute (Carew & Therese, 2007; Carew, et al., 2009; Hadgraft, et al., 2008). But, as Carew and Therese (2007), and Carew et al. (2009) have asserted, limited efforts have been made in engineering education to contextualise systems thinking as a multimodal competence. Carew et al. (2009) have argued that efforts to contextualise systems thinking as a competence within specific engineering disciplines have been limited owing to a combination of influences.

These influences include the lack of time and resources as well as lack of rewards and incentives to educators to engage in such inquiry; a general lack of ownership and responsibility toward the development of systems thinking in an already compressed curriculum as well as a reluctance to attend to its development owing to an overt preference toward other particular competences; and habituation to educating in particular ways – premised on particular philosophies of engineering education and engineering practice – that seems to ignore the contemporary need to critically rethink pedagogies in favour of those likely to enthuse and inspire students to engage authentically and deeply with holistic and complex competences like systems thinking.

I considered these influences – which limit efforts to contextualise systems thinking as a competence in disciplinary terms –as the arsenal of reasons that motivated the conduct of my inquiry into how systems thinking can be taught, learned, assessed and evaluated as a competence within chemical engineering, particularly in PRM.

Given the recent acknowledgement that research into how competences can be promoted and developed through formal and informal educational experiences has emerged as an important line of engineering educational inquiry (Borrego & Bernhard, 2011; Litzinger, et al., 2011; Walther, Kellam, Sochacka, & Radcliffe, 2011), prospective researchers have been encouraged to ask penetrating questions that interrogate, expose and explore fundamental assumptions that underpin educational decisions (Adams et al., 2011; Baillie, Ko, Newstetter, & Radcliffe, 2011; Borrego & Bernhard, 2011). Research ought to ask questions "that are patently needing to be asked" (Case & Light, 2011, p. 190), and as shown below, these are the kind of questions being addressed though this inquiry.

1.2 Objectives of Inquiry and Guiding Questions

Fundamental and penetrating questions need to be asked about engagement and development of systems thinking in PRM education. With this in mind, this inquiry proceeds along two interrelated lines.

The first line of inquiry seeks to define and better understand systems thinking in the context of PRM education. In this approach, systems oriented ideas from non-engineering disciplines are combined with systems oriented ideas from PRM education to develop a conceptual framework of what systems thinking entails in the study and practice of PRM.

This strategy is inspired by Hadgraft et al's (2008) recommendation that alternative systems ideas found outside engineering disciplines can be productively engaged and combined to produce newer perspectives and insights into how the systems idea can be meaningfully developed as an educational concept in engineering education.

The second line of inquiry seeks to define and better understand how systems thinking can be meaningfully engaged and practiced in the classroom context. In this approach, contemporary theoretical and practical advances in educational competence development are examined to develop a practical framework of how systems thinking can be engaged through activity oriented study and practice of PRM.

This strategy is inspired by recent developments in higher education that urge educators to recognise that competences are holistic in nature and that a situative, sociocultural, process oriented view is more conducive for formal educational competence development than traditional behaviourist and cognitivist learning perspectives (Dall'alba & Barnacle, 2007; Dumont, Istance, & Benevides, 2010; Haggis, 2009; Illeris, 2009d).

Following on from the above lines of inquiry, the following set of questions have been developed:

1. How can systems thinking be construed in the study of PRM situations?
2. How can systems thinking be implemented in the study of PRM situations? Or, what kind of pedagogic and assessment practices does an educator need to implement to encourage systems thinking in the study of PRM situations?
3. How can an educator ascertain that students are engaging in systems thinking in the study of PRM situations? Or, what kind of evidence does an educator need

to gather to ascertain that students are engaging in systems thinking in the study of PRM situations?

Questions, like those above, are pragmatic, significant and need to be investigated if the call for greater research and discourse on systems thinking in disciplinary engineering education is heeded seriously. This thesis addresses these three pragmatic questions.

1.3   Significance of Inquiry

This specific inquiry is significant owing to three interrelated reasons. Firstly, it accepts that systems thinking is identified and acknowledged as a core competence for graduate chemical engineers of the 21st century and figures prominently in the chemical engineering curricular agenda (IChemE, 2012) and is in need of greater pedagogic research attention (Carew & Therese, 2007; Carew, et al., 2009; Hadgraft, et al., 2008).

The second reason is that, given that PRM education is acknowledged as a vital aspect of contemporary chemical engineering education, there is now a well-recognised need to teach PRM in a holistic, systems oriented manner rather than the prevalent purely technical pedagogic approach (Cameron, 2005; IChemE, 2012; Perrin & Laurent, 2008; Skelton, 1997). And thirdly, in-depth studies concerning the engagement and development of systems thinking in PRM education are currently unavailable to guide educators on practical pedagogic decisions. Taken together, these reasons provide the vital incentives for this inquiry.

I undertook this inquiry motivated by the above incentives as well as a desire to offer a meaningful and scholarly contribution to systems education discourse, which is concerned with pedagogic practices relating to the education of systems thinkers.

In this thesis I present a contextually relevant, well-reasoned holistic response to the guiding questions highlighted in the preceding section.

1.4   Methodology of Inquiry and Focus

The situational aspects of this inquiry, its objectives, the specific guiding questions being pursued and their significance, are crucial influences on the methodology of inquiry. Taking these matters into account, a distinctly interpretive approach has been adopted. The term "bricoleur" best captures the mode of operation adopted for this inquiry (Denzin & Lincoln, 2005a; Kincheloe & Berry, 2004; Kincheloe & McLaren, 2005).

In an inquiry of this nature, the inquirer becomes a bricoleur when he or she blends more than one methodological tradition to develop a hybrid methodology that is contextually appropriate and situation specific. This hybrid methodology of inquiry and the eventual methods by which evidence is gathered, interpreted, and presented are understood as emergent constructions, developed in the course of the inquiry itself and not pre-determined.

As Kincheloe and McLaren observe, methodological strategies are employed as needed in the unfolding context of the research situation and involve "construction and reconstruction, contextual diagnosis, negotiation and readjustment" (2005, p. 317). The inquirer's posture and mode of engagement in the inquiry is as a "passionate participant"(Guba & Lincoln, 1994, 2005).

In the course of this inquiry, dwelling constantly on its means and ends in light of the context, objectives and questions, practices from two methodological traditions have been adapted. The hybrid methodology combines hermeneutics (Schwandt, 1993, 1994, 2004; J. K. Smith, 1993), and narrative inquiry approaches (Clandinin, 2007; Polkinghorne, 1988; Riessman, 2008; Watson, 2012). These have been used in combination owing to their common grounding in the socio-constructionist and interpretivist paradigm.

Following on from the above methodological orientation, the focus during the inquiry is on exploring the process of engagement involved in the practice and understanding of systems thinking in PRM at the classroom level. It privileges the contemporary turn toward a process oriented view of educational competence development (Dall'alba & Barnacle, 2007; Walther, et al., 2011).

It attends to the need to understand engagement and participation in particular pedagogic activities and resulting patterns of interactions that facilitate as well as hinder engagement with systems thinking in PRM at the classroom level.

Decisions on methodological matters as well as specific methods for data gathering, interpretation, and presentation are discussed in Chapter 2.

1.5   Thesis structure

Chapter 2 addresses in detail the methodological aspects of this inquiry. Given that the inquirer operates in this inquiry as a bricoleur, and the methodology of inquiry is

constructed as the research context unfolds, these decisions are presented in retrospect.

Chapter 3 explores the notion of systems thinking as a competence within PRM education. It presents a conceptual framework as a possible way to re-contextualise systems thinking in PRM. Questions are raised about systems thinking in a definitional sense so that it is better understood as a process of arriving at a meaningful understanding of risk management situations. In this chapter I address my inquiry's first guiding question.

Chapter 4 proceeds to examine how the reconceptualised notion of systems thinking from the previous chapter may be developed and assessed through particular educational experiences. It focuses on identifying and justifying pedagogic and assessment strategies that are appropriate for engaging systems thinking in PRM. An activity-oriented pedagogic approach to engage systems thinking in PRM is presented. In this chapter I address my inquiry's second guiding question.

Chapter 5 demonstrates how the above activity-based pedagogic approach was implemented in the course of this inquiry. The objective here is to show that students who engaged in these activities were developing the ability to think systemically. Exemplars of student responses will be presented to demonstrate systemic thinking in action. In this chapter I address my inquiry's third guiding question.

Chapter 6 tackles the challenges and worldview transformations that some student participants experienced when intently and attentively engaged in systems thinking in the above activity-based PRM educational experience. In this chapter, like the one preceding it, I address my inquiry's third guiding question.

Chapter 7 is the concluding chapter. It consists of five sections. In the first three sections, I revisit my inquiry's guiding questions and briefly highlight the insights that flashed forth in the pursuit of each line of inquiry. The fourth section focuses on a set of recommendations that I have developed as a result of my inquiry. And in the final section, I bring the thesis to a close by highlighting some constraints of my inquiry, and subsequently summarise my contributions to the topic of inquiry.

2 Methodology of Inquiry: A Retrospective Narrative of Stances and Strides, Steps and Standards of Quality Pursued

The contemporary qualitative inquirer operates in an era of paradigm proliferation (Denzin & Lincoln, 2005b; Taylor, 2014; Taylor & Wallace, 2007). The inquiry space is, as Denzin and Lincoln (2005a, p. 20) put it, "politically charged". Methodological choices and decisions can be contested and justifications will be sought. Qualitative inquiry is not simply an epistemological enterprise, it is a complex, practical and moral activity too (J. K. Smith & Hodkinson, 2005). The inquirer makes practical and embodied judgements throughout the conduct of his or her inquiry (Beckett & Hager, 2002; Schwandt, 2005).

Within this politically charged space of practice, contemporary qualitative inquirers are increasingly expected to make themselves visible in their inquiries and to articulate their processes and practices of inquiry as explicitly and clearly as possible. In doing so, they enable the audience of their inquiries to evaluate the quality of their contributions toward the advancement of knowledge and understanding on their chosen inquiry topics and the rigour with which the inquiry is conducted. However, given the diversity of paradigms, epistemologies and methodologies of inquiry, both the inquirer and his or her audience also face a daunting choice from among numerous quality standards by which to evaluate the inquiry at hand and its outcome.

To avoid having to defend incorrectly chosen and applied standards, it is now seen as particularly prudent for the inquirer to recommend the quality standards he or she deems most appropriate. This is best done when the inquirer proactively makes a case for his or her preferred quality standards, by demonstrating a strong correlation between the standards and the purposes, premises and practices involved in the inquiry. This, again, is best done when the inquirer can make his or her process of inquiry visible (Freeman, deMarrais, Preissle, Roulston, & St. Pierre, 2007; Taylor, 2014; Toma, 2011).

In this chapter, I aim to make my processes and practices of inquiry visible and identify the standards of quality by which this doctoral inquiry ought to be evaluated. In order to reflect my processes and practices as emerging from the topic of inquiry and the specific questions being pursued, I explicate my decisions in terms of stances, strides and specific steps taken in the conduct of this inquiry, and standards of rigour embedded and pursued.

2.1 Stances and Strides in this Inquiry: A Hermeneutical Approach

I have pursued the resolution of three questions in this doctoral inquiry. These questions have been articulated in the introductory chapter. In having framed the questions as I do, I also implicate a web of assumptions. These assumptions cover various aspects of the inquiry, such as the focus, scope, nature, process of inquiry as well as the attitudes, attributes and competences I have needed to mobilise for this inquiry.

Taken together, these operating assumptions propel the inquiry by particular means to achieve particular ends while constraining its progress along alternative paths. This web constitutes what is known as the inquirer's paradigm or worldview, and defines the ontological, epistemological, and methodological bases that found and guide this inquiry (Guba & Lincoln, 2005). In the interest of brevity, these assumptions are stated below without explanations.

This inquiry operates within the constructivist-interpretivist paradigm of human inquiry (Schwandt, 1994). It accepts a relativist ontology in the sense that the inquirer acknowledges multiple, constantly shifting realities rather than there being a singular absolute reality (Ely, Anzul, Friedman, Garner, & Steinmetz, 1991; Guba & Lincoln, 2005).

I subscribe to a transactional, interpretive epistemology because I believe that the knower and the known interact and shape one another (Guba & Lincoln, 2005). The inquiry forms and transforms in the ongoing transaction between what the inquirer does, learns and feels in the course of the inquiry (Ely, et al., 1991). Accordingly, as an inquirer I have adopted a hermeneutic stance for my inquiry.

An inquirer adopts a hermeneutic stance of inquiry when the primary aim of inquiry is to understand a particular experience from the point of view of those who lived, felt and underwent it (Schwandt, 1994). However, it is an understanding of the interpretive kind in that the inquirer accepts that to understand a human experience involves having to interpret it, to construct a reading of the language and actions of the human actors in that experience and to offer it to the inquirer's audience in a manner so as to refine our ordinary understanding of that human experience (Schwandt, 1999).

Broadly speaking, as stated in the introduction, my inquiry sought to resolve a practical concern: how can systems thinking be taught, learned, assessed and evaluated as a competence in PRM? It meant having to experientially explore the pedagogic process

involved in the engagement of systems thinking in PRM. I needed to understand engagement and participation in particular pedagogic activities and interactions that facilitate as well as hinder engagement with systems thinking in PRM.

What makes the hermeneutic stance particularly appropriate for my inquiry is that it does not require the inquirer to have any special training as an interpreter of human language and action. Instead, it assumes that the interpretive act is so fundamentally innate to all human beings that the inquirer and those being inquired share this ability and are similarly adept at it (Schwandt, 1994). We are interpretive beings and the interpretive act is an ontological necessity (Macmurray, 1933). When we try to understand the cultural world, we are dealing with interpretations and interpretations of interpretations (Rabinow & Sullivan, 1987, p. 7).

The hermeneutic stance, however, actively evades prescription. According to Smith (1993), it is an open encounter that cannot be distilled into a series of how-to-do-it rules. Inquiry is thought of and enacted very differently from the traditional conceptions of scientific inquiry. To the inquirer, the inquiry is not simply a cognitive craft pursued with methodological precision and control, rather it is an immersive experience composed of a series of events in which the inquirer wholly participates and is open to being transformed in the process (Schwandt, 2004).

Smith (1993, p. 197) insists that a hermeneutic inquiry "is a practical task and understanding is very much a practical accomplishment." The inquirer has to deliberate thoughtfully, resort to practical and ethical reasoning and powers of judgement, and exercise care and empathy throughout the inquiry (Dunne & Pendlebury, 2003; Granek, 2011; Schwandt, 2004). The inquirer is ever mindful of the linguistic, cultural and historical contexts within which the chosen human experience is situated (Donald, 2011; Jardine, 1992a, 1992b).

The hermeneutic inquirer begins, returns to, and is guided constantly by the topic of inquiry. The topic of inquiry has been in existence long before the inquirer set upon it. Hence, the inquirer allows oneself to be addressed by the topic (Gadamer, 1975, 1976, 1981). The inquirer recursively questions what is already known, available, presumed and understood in order to arrive at what is new, strange, and unfamiliar to the inquirer. In this way the inquirer's understanding moves with a deeper sense of the interconnectivity of the topic (McCaffrey, Raffin-Bouchal, & Moules, 2012).

I ventured into my inquiry in the same way. Reiterating a point stated early in my thesis introduction, systems thinking is the idea that animates my inquiry. Systems thinking is, therefore, the topic of my inquiry, and every chapter of this thesis represents my excursions in, about, around, and through this topic.

A hermeneutic inquirer regards and explores the topic of inquiry as a living topic, one that has been in existence for several decades and has developed from infancy to its currently mature form. The topic has a historical, linguistic, and cultural lineage which the inquirer can fruitfully explore in order to cultivate his or her understanding (Jardine, 1992b, 1998; Schwandt, 1999).

Systems thinking is a living topic, in the course of well over a century it has been appropriated and practiced in various ways in various disciplines. What unites these diverse disciplinary manifestations, however, is the understanding of the systems idea (Checkland, 1999; Churchman, 1968; Flood, 1999; Jackson, 2003; Midgley, 2003; Ramage & Shipp, 2009).

I explore this ancestral understanding of the systems idea, taking different routes. I started first from where I was situated – within the discipline of engineering education. This excursion is evident in Chapter 3. In it, I explored how systems thinking has come to be understood in engineering education. I took the opportunity to question whether the questions I wished to pursue in my doctoral inquiry were worthwhile. It provided key turning points for my inquiry. Not only did I realise that my questions are worthwhile, I also discover that I ought to pursue those questions in two ways.

Firstly, I directed my attention to a greater extent toward systems thinking as it has been understood in areas beyond engineering. In doing so, I realised that one has the freedom to reconceptualise systems thinking for particular purposes. The main thing is that one ought to remain true to the core philosophical idea that underpins systems thinking and develop practices that best align with that idea.

I pursued this line of inquiry in Chapter 3. I drew on the writings of various systems thinkers in order to propose the notion of *Systemic Thinking* as an epistemic competence with specific commitments that a person enacts while staying true to the core philosophical idea of systems thinking. By drawing on literature on societal risk and safety theory and practices

I then situated systemic thinking as the epistemic competence that underpins risk thinking in PRM situations. As a result of this phase of inquiry I developed the conceptual framework that guided me onward to the next phase, which coincides with the second key turning point.

My second turning point in this inquiry followed closely from the exploration of engineering education literature. It prompted me to further inquire into the processes and practices of educational competence development. This redirection chiefly owed to the repeated construal of systems thinking as a professional competence.

Accordingly, I pursued this aspect of the inquiry by attending to contemporary theoretical and practical advances in the understanding of complex and holistic competences. I undertook this exploration in Chapter 4.

In Chapter 4, I drew on a situative, sociocultural, process oriented view of formal educational competence development to propose an evidence-based practical framework by which systems thinking can be developed in an activity-oriented PRM learning environment.

Given that this inquiry was aimed to accomplish practical pedagogic ends, I considered it imperative to undertake further inquiry to examine whether the conceptual and practical framework led to anticipated student learning experiences. In this phase of hermeneutic inquiry, I carefully attended to the matter of methods by which to best gather the experiential understandings of my students in the course of their PRM activity-oriented learning interactions.

My decisions on which data resourcing methods were chosen are made explicit in companion chapters 5 and 6; they are not discussed here. I urge interested readers to attend to those chapters for the situated and context-sensitive details about those methods.

In the foregoing discussion, I focus on yet another turning point relating to the practices by which I "made sense" (Marshall, 1981; Rowan, 1981) of the data gathered from various methods. I describe below how reading, writing and narrativising became integral interpretive practices for this phase of my inquiry.

In hermeneutic inquiry the matter of methods (techniques for what is traditionally known as data collection, sampling, analysis, interpretation and presentation) is addressed differently from traditional scientific inquiry practices.

To the hermeneutic inquirer, these are not distinct and sequential activities; rather they are enfolded continually into every interpretive move throughout the inquiry. The approach permits the inquirer to choose and use a variety of methods, because the inquiry is question oriented rather than methods based.

Methods are simply means by which data are gathered or sourced. What is gathered is not yet data, nor is data "analysed" in the traditional reductionist sense. Instead, the inquirer constructs data from what is gathered through the act of interpretation (Erickson, 2004; Koch, 1996). Here, as Erickson (2004) argues, multiple interpretations are possible and there is no special formula for choosing wisely amongst methods.

The inquirer's temperament, prior experience, personal idiosyncrasies, and intimacy with wide ranging literature converge to ascertain the interpretation that most befits the context and advances understanding of the topic inquired.

Interpretive understanding is an event that arrives upon the inquirer, it is epiphanic (Jardine, 2008a). It emerges in the course of a deep immersion one experiences in recursively reading, reflecting and writing on, about and around the topic of inquiry (Moules, 2002).

The inquirer reads and re-reads literature so as to cultivate an intense intimacy with the topic. As McCaffrey et al. (2012) point out, the effort here goes beyond obvious sources as is expected in a conventional literature review, to include whatever is reasonably practicable to illuminate the topic.

The chief interest is to cultivate a richer, nuanced understanding of the topic. The inquirer reads meticulously in order to court insight, for as Jardine (2008a, p. 110) tells us, it is most likely to flash forth only when the topic has become "familiar, cellular, memorable, at the tip of the tongue in immediate ways."

I, too, immersed myself to read and re-read both the data, my conceptual and practical framework that purposively informed the gathered data, and the wider range of literature to which I had turned in order to develop those frameworks.

I committed seriously to the hermeneutic call to be scholarly, and meticulous, and to pleasurably cultivate familiarity with one's topic.

The same interest and commitment compels the inquirer to write just as meticulously. Writing further deepens the inquirer's understanding of the topic because his or her texts become sites for the making of connections, and to responsibly explore the biases, premises, and perspectives encountered in the experience of literature as invaluable points of departures for further inquiry.

For the inquirer, writing interpretively becomes a profoundly pedagogic, educative, and transformative venture (Jardine, 1992a, 1998; Misgeld & Jardine, 1989). Writing becomes a means of inquiry and discovery resulting in a "deepened, complex, and thoroughly partial understanding of the topic"(Richardson & St. Pierre, 2005, p. 963).

In my inquiry, I envisioned topics such as systems thinking and its practice, educational competence development, and teaching-learning-assessment-evaluation practices in higher education as living practices premised on a network of beliefs. And I also envisioned my inquiry into these topics, inspired by Rorty (1991, pp. 93-110), as the "reweaving of the webs of beliefs" by which the topic can be interpretively understood. In the interest of deepening my own understanding, I have written each thesis chapter to reveal the reweaving of the webs of topical beliefs.

I soon found myself at a point where having accessed various sources of data, I had to dwell in and on them to figure out how best to construct and showcase evidence of what my students had said and done during the workshops (see descriptions in Chapter 5) I conducted in the PRM course from which I could reliably draw inferences about the development of systemic thinking.

The twin practices of reading meticulously and widely and writing descriptively were to provide the next key turning point. The turn to narrativising precipitated from the above twin interpretive practices.

The narrative impulse is ubiquitous to everyday life in that we "dream in narrative, daydream in narrative, remember, anticipate, hope despair, believe, doubt, plan, revise, criticise, construct, gossip, learn, hate and live by narrative" (Hardy, 1977, p. 13). It is a fundamental human capacity by which we remember, argue, justify, persuade, engage, entertain, mislead or mobilise others, and even foster a sense of belonging (Riessman, 2008).

As a cognitive process narrative draws together human actions and the events that affect human beings, and in doing so creates meaning by organising human experiences into temporally meaningful episodes wherein contributions of particular actions and events are related to particular outcomes or consequences (Polkinghorne, 1988).

This makes narrative a versatile, multi-situational resource for thought that enables people to think about specific situations by meaningfully organising events in terms of relations between objects, agents, and actions (Herman, 2003a).

A narrative affords us three conveniences. First, it enables us to make sense of experiences and situations. This, as Polkinghorne (1988) tells us, occurs through emplotment, that is, an event is understood when the physical, historical and social context in which the event took place is taken into account by means of a coherent plot that weaves human goals, motives, and agents in relation to the opportunities afforded by the physical, cultural and personal environments.

Secondly, it enables us to explain human activity in terms of situated and contextual actions. Emplotment, as mentioned above, is not merely a sense-making tool, it is explanatory as well. Narrative explanation is powerful because it provides us access to and appreciation of context (Tsoukas & Hatch, 2001).

Polkinghorne (1988) also concurs on this point, observing that when a human event is said not to make sense, the difficulty usually stems from a person's inability to integrate the event into a plot whereby it becomes understandable in the context of what has happened. Furthermore, as Tsoukas and Hatch (2001) and Polkinghorne (1988) have argued, narrative is not only capable of accounting contexts; it is equally able to highlight temporal changes for we cannot explain why something is the way it is without explaining how it got to be that way. To know why necessitates knowing how, and this in turn demands a historical perspective which is best captured through temporal narratives.

Thirdly, it enables us to communicate with others. Narrative is a common yet significant mode of communication in social life since it allows us to make sense of social action (Czarniawska, 2004). According to McEwan and Egan (1995) it serves the purpose of communicating who we are, what we do, how we feel, and why we ought to follow some course of action rather than another, and in that sense, narratives are both instructive as well as informative.

We use narratives all the time because social reality presents itself to us largely as a narrative, for that is how we, as social beings, seem to naturally make sense of complex social situations every day of our lives (Gudmundsdottir, 2001).

The above three affordances are crucial to how one navigates and negotiates a complex, ill-structured situation, particularly if that situation is to be responded to by ethically defensible actions. In such a situation, the turn to narrative is indispensable because, as Tsoukas and Hatch (2001) have argued, our understanding of a complex situation will always be grounded in the narratives we (as observers and/or participants) construct about it, and if we are to successfully resolve the situation then attention must be directed to the exploration and examination of the multiple narratives that populate the situation. Narratives are, after all, perspectives of a narrator, that are not only grounded in the narrator's worldviews but are also a primary source of building and updating worldviews. Narratives are a highly adaptable resource for problem-solving and assessing counterfactual, what-if scenarios (Herman, 2003b).

Furthermore, as has been argued elsewhere by several authors, attention to narratives is particularly beneficial to resolution of disagreements in a complex situation because practical reasoning, which constitutes a significant part of any competent professional practice, is also largely narrative in form (Beckett, 2004, 2009; Clandinin & Connelly, 1991; Dunne & Pendlebury, 2003; MacIntyre, 1981; Mattingly, 1991; McEwan & Egan, 1995; Pendlebury, 1995; Perrotta, 2009).

Whenever one hopes to understand a complex situation, it appears useful to trace out the narratives that inform the actions and practical judgments of the people and institutions involved, for these narratives provide the best clues of why people act as they do (Hinchman & Hinchman, 1997). In this inquiry, the key stances and strides, as described above, required me to work carefully in the narrative dimension. In the following section, I describe the specific steps I had to take in order to develop Chapters 5 and 6 in which the bulk of the data gathered in this inquiry is showcased.

2.2   Specific Steps in this Inquiry: Treating Narratives

I ended the previous section by pointing out how and why the narrative turn precipitated as a natural consequence of my hermeneutic stance. In this section, I define what I take as a narrative and how I subsequently treated it as a unit of interpretation.

The steps discussed here were taken to produce Chapters 5 and 6 which prominently feature inquiry participants' narratives.

Drawing on Polkinghorne (1988, 1995) and Riessman (2008), I chose to understand a narrative as that spoken or written expression that consequentially links events, series of events, or ideas, by imposing a meaningful pattern on the above occurences. This is the basic requirement of what constitutes a narrative. Beyond that, a narrative is operationally defined by how it is used.

Riessman (2008) in fact cautions us against expecting a simple, clear definition of narrative in the presence of a range of definitions. The definition I adopted expresses the most widely accepted feature of narrative (Ryan, 2007). In addition to the above fundamental feature, operationally I took a narrative as that descriptive, storied account by which events and experiences, situations and situated actions, and people are related in a way that makes sense, is both explanatory and communicative, and aides in the growth of understanding.

By that I mean, for example, in terms of events and experiences, following Elliott (2012) and Herman (2007), if a written or spoken linguistic expression provided an account of meanings of events and experiences from a person's perspective, describing what happened to particular people and what it was like to experience what happened in particular circumstances with specific consequences, I considered it a narrative.

In terms of situations and situated actions, following Polkinghorne (1995), if the expression provided an account of attempts to progress to a solution, clarification or unravelling of an incomplete situation, depicting an activity as purposeful engagement and a situated action as the outcome of the interaction of a person's previous learning and experiences, presently-situated presses, and proposed goals and purposes, I considered that too as narrative.

Further, in terms of people, following Ryan (2007), if what was expressed depicted an evolving network of human relations and presented the order in which events occurred, what changes they caused to those involved, what those events and their consequences meant for those people, what motivated their actions and how the outcome of those actions compared with their prior intentions, then that was construed as a narrative as well.

Narrative data similar to the kind highlighted above constitute the units of analysis, and the analytic approach used is widely referred to as narrative analysis (Cortazzi & Jin, 2012; Polkinghorne, 1988, 1995; Riessman, 1993, 2008; Watson, 2012).

However, as pointed out by Cortazzi and Jin (2012) and Riessman (2008), it is important to note that several methods are available to conduct narrative analysis, with some that focus on meaning, others on the structure and yet others on social interaction and the context, and some that combine foci or develop a method suitable to particular inquiry purposes, the kind of narratives and a preferred style of qualitative inquiry.

The onus, therefore, is certainly on the inquirer to describe the favoured analytic method. But, while it is the inquirer's responsibility and imperative to outline the method employed, it must be acknowledged by both the inquirer and the intended audience that analysing narratives is a complex holistic practice for which no definitive guidance can be given (Watson, 2012).

Narrative analysis is about interpretation, and as Riessman (1993) has observed, there is no canonical approach in interpretive work, no recipes and formulas or standard set of procedures. What the researcher can describe in terms of a method is best considered as a set of heuristic guidelines or features of the analytic method. Therefore, what follows below is a set of interrelated guidelines or features that outline my own narrative analytic approach.

Given its interpretive nature, as Riessman (1993, 2008) has observed, analysis is slow and painstaking, requiring attention to subtlety particularly in relation nuances of language. In fact, Watson (2012) has argued that when approaching narrative data what is primarily required is to be open, yet attentive, and to be reflexively alert while conducting analyses.

A related point to the one above is that a narrative is itself an interpretive construction organised in a special way by the narrator for his or her intended audience. Narrative functions as an act of telling someone something (Gudmundsdottir, 1995, 2001). However, no one can tell all there is to tell, hence as Schön (1991a) has noted, a narrator privileges some perspectives and neglect others, fixing attention on one phenomenon and ignoring or giving fleeting attention to others depending upon his or her motivating purposes. This renders any given narrative as simply one way of looking at things. Consequently, narrative analysis is always necessarily perspectival.

Bearing in mind the perspectival nature of narrative analytic work, the aim of the analytic enterprise is to provide a deeper understanding and appreciation of human interaction as it evolves in particular context-specific situations (Gudmundsdottir, 2001). The purpose of narrative analysis, according to Polkinghorne (1995), is to provide a dynamic framework in which a range of narrative data are made to cohere in an interesting and explanatory way so as to provide the reader or the inquirer's audience with insight and understanding.

A crucial step toward fulfilling the above purpose is to develop a narrative explanation by utilising the previously discussed affordances of narratives. Mattingly (1991) has argued that what narratives do best is tell how and why something happened by showing how, with actions presented as though unfolding diachronically while also revealing contexts and lives. Narratives, as Mattingly has emphasised, connect particular events chronologically, thematically and teleologically.

Likewise, narrative analysis has access to the same approaches to building a narrative explanation. It can be undertaken temporally, thematically, and purposively. Narratives exhibit an explanation instead of demonstrating it, and a narrative explanation configures narrative data into a story-like causal nexus (Polkinghorne, 1988).

Consequently, my approach to building a narrative explanation has drawn heavily on Polkinghorne's (1995) method of narrative configuration, the process by which relevant narrative data elements are drawn together into a temporally organised, thematically threaded, systemic whole.

The analytic task requires the inquirer to organise the narrative data elements into a coherent developmental account. In my inquiry context, it meant I had to show the development of systemic thinking and the transformation of worldviews toward a systemic outlook through specifically designed and facilitated learning activities and assessment experiences (see narratives in Chapters 5-6).

The configurative process, which as Polkinghorne (1995) has explained, employs a thematic thread, referred to as a plot to guide the integration of various narrative data elements. In my inquiry context, I plotted to show systemic thinking as an epistemic approach to better understand PRM situations, because systemic thinking is primarily a conceptual approach to learn about and understand complex, ill-structured situations in

order to act in an ethically defensible manner when intending to improve those situations (Checkland, 2003; Churchman, 1968; Flood, 1999).

With that plot in mind, the process of narrative analysis was more a synthesis of narrative data elements that contribute toward the advancement of the chosen plot, and required me to recursively move between narrative data and the chosen thematic plot.

While so doing, the plot accordingly informed me about which items from the gathered data should be included or excluded while building the narrative explanation. Riessman (2008) has stressed that since the focus in on developing and advancing the plot the emphasis is on integrating positive narrative data elements (those befitting the plot) into the developing narrative while the negative ones (those that may not necessarily contradict the plot, but are impertinent to its development) are eliminated.

Finally, the outcome of such narrative analysis is, as Watson (2012) has remarked, itself a narrative. Polkinghorne (1995) refers to it as an emplotted narrative because the plot provides systemic unity to the narrative data. Furthermore, as Polkinghorne has pointed out, the inquirer is the narrator of that emplotted narrative and may freely draw on any relevant theoretical literature to argue and defend his or her interpretations. This invests the emplotted narrative with explanatory power (Clandinin & Connelly, 1991, 1994; Connelly & Clandinin, 1988, 1990), and when done skilfully the interpretive work is potentially epiphanic (Dunne & Pendlebury, 2003) or revelatory (Packer, 1985). Accordingly, the value of the resulting narrative depends on its capacity to provide its reader with insight and understanding (Polkinghorne, 1995).

For me the narrative turn has been a challenging undertaking which, as Watson (2012) cautions, is complicated by the fact that in this inquiry narrative is equally the phenomenon or process being studied, the methodological approach adopted for analysis, as well as the means of representation of the inquiry findings.

However, in the course of reading, writing and narrativising I became convinced that narratives excellently exhibit the complexities of situated human actions and practices such as those pertaining to competence development (Beckett, 2009; Dunne & Pendlebury, 2003; Gudmundsdottir, 2001; Mattingly, 1991; Pendlebury, 1995; Perrotta, 2009). This is particularly attributed to the fact that both competence development as it is contemporaneously understood and the narrative project are grounded in the

situative or cultural-historical activity oriented perspective of cognition and learning (Dunne & Pendlebury, 2003; Gudmundsdottir, 2001; Hager & Hyland, 2003; Schwandt, 2005).

Narrative is the vital bridge between language and cognition that allows us to analyse and reflect on complex social situations and practices. A narrative offers us an opportunity to not only understand but also potentially improve those complex social situations and practices (Gudmundsdottir, 2001). Arguably, the fact that narratives can display and capture experience, time, personal knowledge, reflection and deliberation (Clandinin & Connelly, 1991), all of which, incidentally, together constitute competence as it is holistically conceived (Beckett, 2009; Jarvis, 2009), only serves as yet another incentive in addition to the benefits discussed in the preceding section to undertake the narrative analytic adventure.

2.3 Standards of Rigour Embedded and Pursued in this Inquiry

A worthwhile educational inquiry is rigorous. But, what makes for rigour? Contemporary discourse and understanding on rigour in qualitative educational inquiry suggests that given how furiously this issue is contested, I would be wise to regard rigour as interpretable and constitutive (Freeman, et al., 2007; Lather, 2001; Morse, Barrett, Mayan, Olson, & Spiers, 2002; Taylor, 2014; Toma, 2011).

As an educational inquirer, the more pertinent questions for me to ask instead are: What do I constitute rigour to be? And, what practices do I enact to approach it? In asking these questions, I responded to Toma's (2011) invitation to qualitative educational inquirers to develop standards related to rigour that are most sensible, meaningful, and purposeful to me and resonate with the beliefs and values that underpin my current inquiry.

However, arriving at the inquiry standards to which I ought to commit is no easy feat to accomplish. One is spoilt for choice given the diversity of competing standards (Denzin & Lincoln, 2005a). Just as the conduct of an inquiry is construed as being complex, practical, moral, political, and all pertinent decisions in that regard are contestable, so too is the choice of standards to which an inquirer commits (J. K. Smith & Hodkinson, 2005).

My decision, drawn from generally proffered advice found in literature on this matter, has been to consider and enact standards and practices that strongly fit with the purpose or ends of my inquiry, the inquiry paradigm within which I operate, and the inquiry approach taken (Altheide & Johnson, 1994; Guba & Lincoln, 1994, 2005; Morse, et al., 2002; Taylor, 2014; Toma, 2011).

This inquiry and this thesis are animated by one overarching purpose: the pursuit of understanding. It is the most important standard to which I have committed. This standard is a perfect fit for my inquiry because the aim of interpretation is to develop and communicate an authentic emotional understanding – whatever the topic of interest may be (Denzin, 1994). Epistemologically speaking, all we can possibly strive for is the broadening, deepening, growth and advancement of understanding (Elgin, 1996).

The same concern also compels and propels me as a hermeneutic inquirer because hermeneutic inquiry, too, is a quest for a deeper, nuanced, and richer understanding, it is ultimately pedagogic and educative (Jardine, 2012; Jardine, Clifford, & Friesen, 2008). To me both the inquiry and the thesis have been profoundly pedagogic and educative. This thesis, therefore, exhibits both the process of coming to understand my topic of inquiry as well as the outcome of that process. I seek to communicate my understanding of the topic and the resolution of the questions of my inquiry to the reader. With that in mind, I have developed a set of related questions drawn from relevant literature that has informed my sense and practice of rigour in relation to the above commitment. A reader may ask of one's self the following questions to evaluate this thesis:

- Does it contribute to, deepen, or effect a change in understanding about the topic of inquiry and the practical concern that animates the inquiry (Packer & Addison, 1989; Polkinghorne, 2007; Richardson & St. Pierre, 2005)?
- Is it illuminating (Reason, 1981)?

Interpretive understanding, the kind exhibited here, is characteristically practical. Both the inquiry and my thesis advance by way of practical reasons (Dunne & Pendlebury, 2003; R. Smith, 2006). This is the way of a hermeneutic inquirer (J. K. Smith, 1993). In this thesis, I have reasoned and thought aloud in the narrative mode, and chapters are thickly descriptive, thus reflecting the "strongly hermeneutic character" of this inquiry (Dunne & Pendlebury, 2003, p. 203).

It is only through thick description that the interpretive, situational, contextual, relational, local, particular, salient, processual, reflexive, and intentional character of this inquiry become evident (Altheide & Johnson, 1994; Cho & Trent, 2006; Denzin, 1994; Dunne & Pendlebury, 2003; Greene, 1994; Lather, 2001). Bearing this in mind, the reader may also ask of one's self the following questions to evaluate this thesis:

- Is there evidence of interaction between the inquirer, the topic of inquiry, and inquirer's sense-making process (Altheide & Johnson, 1994)?
- Is there recognisable and comprehensible evidence that exhibits the inquirer's decisions, practices, and thoughts concerning the inquiry (Freeman, et al., 2007)?
- Is there persuasive evidence of the cogency of the inquirer's chain of reasoning (Polkinghorne, 1988, 2007)?
- Is there evidence of a scholarly, meticulous, cultivated, and reflexive approach in the inquiry as it unfolds progressively from chapter to chapter (Jardine, 2008a, 2008b; Richardson & St. Pierre, 2005; Riessman, 2008)?

This thesis exhibits my understanding and grasp of the topic of inquiry and the manner in which I have resolved a practical pedagogic situation. My authorial voice is, therefore, undoubtedly prominent, and it claims to an understanding that is at once personal, partial, and perspectival.

However, I also recognise my understanding as relational (Elgin, 1996; Sankey, 2007; Schwandt, 1999). What I make of my topic of inquiry has required that I deliberate over what others make of it. Agreement, of course, is not mandatory, but openness and acceptance of alternative perspectives certainly advances understanding (Elgin, 1996).

Hermeneutic inquirers cannot proceed without this open and accepting stance, for as Greene (1994, p. 439) informs us, they desire to "understand what is being said by all sorts of people," with the excitement that it may just set inquirers up for a "new slant on things, and unexpected vistas may open before them, unexpected dimensions of a problem revealed." My resolve toward the inclusion of multiple perspectives and multiple participant voices is most readily apparent in companion Chapters 5-6. Accordingly, the reader may also ask of one's self the following questions to evaluate this thesis:

- Does the inquirer exhibit his open and accepting hermeneutic stance (Greene, 1994; Jardine, 1992b; Schwandt, 1999, 2004)?
- Is there evidence that multiple perspectives are valued (Eisenhart, 2006; Lather, 2001; Taylor, 2014)?
- Do these multiple perspectives contribute to or advance understanding of the issue at hand (Elgin, 1996; Reason, 1981)?
- Has the inquirer ensured that the voices, viewpoints, and narratives of participants are privileged in addition to his own (Polkinghorne, 2007)?

I invite the reader to judge my inquiry, its outcome, and the form in which it unfolds in this thesis with due regard to the stances, strides and steps I have described in this chapter and elsewhere (see also Chapters 5-6).

The range of questions offered above hint at the commitments and practices I have pursued in the interest of approaching rigour in my inquiry. They address the complex and contentious issue of validity in qualitative inquiry. However, I respond to the issue based on my reading and considered judgement of what it means to conduct an interpretive educational inquiry, and more specifically what it means when proceeding in a deeply hermeneutic manner.

An interpretive inquiry more generally, and a hermeneutic inquiry in particular, is conducted with a reconceptualised sense of validity and rigour, different from the traditional conception of these terms in scientific inquiry.

My concern, therefore, is not to pursue "what is true", but "what is real and reasonable given my situation" bearing in mind that any given situation can be seen meaningfully from multiple perspectives (Elgin, 1996; Greene, 1994; Reason & Rowan, 1981).

The validity of an inquiry derives strength from the awareness, sensitivity, discipline and ethic of the inquirer (Reason & Rowan, 1981; Richardson & St. Pierre, 2005). As a hermeneutically-oriented and narrative-minded inquirer I have strived for interpretive validity (Altheide & Johnson, 1994; Denzin, 1994; Packer & Addison, 1989).

The best I could do was to conduct and document my inquiry such that its resolution and its documentation are perceived as practical, plausible, consistent, coherent, dependable, believable, trustworthy, and persuasive (Moules, 2002; Polkinghorne, 1988,

1995, 1997, 2007; Riessman, 2008). And this is ultimately what I have endeavoured to demonstrate in this thesis.

3   Construing Systems Thinking in Process Risk Management

In the present chapter I address my inquiry's first guiding question: How can systems thinking be construed in the study of PRM situations? To do so, I first examine how systems thinking has been understood and appropriated within the discipline of engineering education. I look to pertinent literature on systems education in this discipline to ascertain a suitable approach to resolve my research questions. Next, I direct my attention toward systems thinking as it has been understood in areas beyond engineering education. I draw on the writings of various systems thinkers in order to propose the notion of *systemic thinking* as an epistemic competence with specific commitments that a person enacts while staying true to the core philosophical idea of systems thinking. By drawing on literature on societal risk and safety theory and practices I then situate systemic thinking as the epistemic competence that underpins risk thinking in PRM situations.

3.1   Educating Graduate Engineers with a Systems Thinking Mindset

Contemporary engineering practice is increasingly seen as multidisciplinary, participatory, and mindful of emerging environmental, economic, and social responsibilities (Rugarcia, et al., 2000; UNESCO, 2010). It is a professional practice that requires engineers to engage with a systems oriented mindset.

Documents from national and international engineering accreditation institutions, for e.g. Engineers Australia (EAustralia, 2011) and the Institute of Chemical Engineers (IChemE, 2012) depict the systemic nature of engineering practice and the kind of the thinking it demands. A professional engineer, according to Engineers Australia (2011), does far more than just technical engineering work. Judgments and decisions have to be made about appropriate materials, processes, systems, technologies and how to integrate all of the above.

Projects have to be thought about over the entire engineering life-cycle, taking what is frequently known as a 'cradle-to-grave' approach, ensuring various projected outcomes are achieved while maintaining the safety of environment and people. And management activities include not only management of resources and activities, but also information and various stakeholders.

A professional engineer takes responsibility for engineering projects and programs in the most far-reaching sense by using a systems thinking approach. Engineers Australia (2011) construes systems thinking as a vital competence that requires a combination of pertinent knowledge, understanding, skills, values and attitudes which can be appropriately activated in particular engineering contexts.

To engage in systems thinking means being able to accommodate, appreciate, identify and understand contexts. Emboldened action verbs (also highlighted below) in the Engineering Australia (2011) competency documentation for professional engineers give a clearer sense of what is involved in systems thinking. Systems thinking engineers are able to:

- **identify and understand** the interactions between engineering systems and people in the social, cultural, environmental, commercial and political contexts in which engineers operate, including both the positive role of engineering in sustainable development and the potentially adverse impacts of engineering activity in the engineering discipline;
- **appreciate** the basis and relevance of standards and codes of practice, as well as legislative and statutory requirements applicable to the engineering discipline;
- **appreciate** the principles of safety engineering, risk management and the health and safety responsibilities of the professional engineer, including legislative requirements applicable to the engineering discipline;
- **appreciate** the social, environmental, and economic principles of sustainable engineering practice;
- **accommodate** relevant contextual issues into all phases of engineering project work, including the fundamentals of business planning and financial management;
- **appreciate** the formal structures and methodologies of systems engineering as a holistic basis for managing complexity and sustainability in engineering practice.

Given that the above description of systems thinking is sourced from a document pertaining to professional engineers in general, it is equally reasonable to inquire whether a similar descriptive focus and conceptual overlap is to be found specifically within the discipline of chemical engineering, which is widely accepted to be a strongly systems-oriented discipline (Hadgraft, et al., 2008; UNESCO, 2010).

A similar descriptive focus and conceptual overlap is indeed clearly present in the descriptions provided in the IChemE's (2012) international accreditation documentation for chemical engineering education.

Graduate chemical engineers from IChemE accredited institutional programmes are expected to have cultivated an appreciation of the wider engineering context - social, environmental, ethical, safety, economical and commercial considerations – that will affect the exercise of their engineering judgment; and they must be able to comprehend the bigger picture and work with an appropriate level of detail in order to mindfully appreciate and manage complex systems and interactions.

Systems thinking is characterised as "broad range thinking" which entails the ability to take a wider perspective on problems and to apply powers of synthesis, analysis, judgment as well as clarity of thinking particularly in the practice of chemical engineering design (IChemE, 2012, p. 31).

Systems thinking engineers are also known to exhibit other pertinent abilities. Their ability to take a wider perspective and contextualise problems makes systems thinkers better able to frame and formulate problems more widely (1988). Because their focus is more on how the problem is viewed, they are correspondingly more intent on holistic problem-solving, they "generate sustainable solutions with broad positive impact, rather than solutions with a positive impact in one area but detrimental side effects in another" (Cattano, et al., 2011, p. 176).

Their focus on problem framing and formulation enables systems thinking engineers to perceive the premises that underpin a complex problem, to understand and describe the problem from multiple relevant perspectives and organisational levels, and to determine changes that are likely to influence a significant improvement with minimum effort (Frank & Waks, 2001).

And systems thinking engineers are strongly ethical, creative and flexible thinkers, possess a strong business sense, are able to empathise with other people, collaborate and communicate effectively, and have an aptitude for lifelong learning (Kellam, et al., 2008).

Although descriptions as above are readily available in engineering education literature about the characteristic modes of thought of systems thinking engineers, the literature also stresses that systems thinking is a challenging competence to develop.

This is in part because it is recognised to be holistic and emergent in nature. It is not to be understood as a single well defined competence. Rather it emerges out of several related competences working together.

Reiterating a key point stated earlier, systems thinking is a combination of pertinent knowledge, understanding, skills, values and attitudes which can be appropriately activated in particular engineering contexts. But, this is precisely why systems thinking is also noted as being conceptually fuzzy and inherently difficult to define and develop at curricular as well as unit and classroom levels in engineering education (Carew & Therese, 2007; Carew, et al., 2009; Hadgraft, et al., 2008).

Some engineering educators interested in the development of systems thinking, however, see its conceptual fuzziness and definitional difficulties as an educational opportunity to demonstrate that the systems idea can be amenably contextualised and reconceptualised in various systems-oriented engineering disciplines, courses and units (Cattano, et al., 2011; Fordyce, 1988; Kellam, et al., 2008; Laporta, 1988; Nehdi & Rehan, 2007; Vanasupa, Stolk, & Herter, 2009).

It is also recognised that activity-oriented, problem- and project-based learning with an emphasis on reflective practice appear to be effective in facilitating the development of systems thinking. These means enable students to practice and apply systems thinking in order to develop their competence in it as well as their understanding of it (Hadgraft, et al., 2008; Kellam, et al., 2008; Litzinger, et al., 2011).

However, in the existing engineering education literature there is little evidence to demonstrate exactly how such means foster the practice and learning of systems thinking. Hence educative endeavours such as those cited above strongly reinforce the message that if engineering educators committed to the development of systems thinking intend to enrich the discourse on best practice in development of systems thinking in engineering education, then they will have to muster their own initiative to define, gather evidence on and discuss what really works in teaching and learning systems thinking in their units and unique contexts.

With the above point in mind, in the following sections I explore the idea of systems thinking as an epistemological process, while also retaining the general characteristics and nature of systems thinking as described in this section. In this way I seek to

contextualise and reconceptualise systems thinking so that it can be suitably practiced and learned in the study of PRM.

3.2 Systemic Thinking: Repurposing Systems Thinking as an Epistemological Process

Descriptions of systems thinking like those presented in the preceding section lack precision in order to be meaningfully implemented at a unit and classroom level. They do not indicate clearly how students are to enact systems thinking competently through classroom activities. Nor do they indicate in certain terms how students are to practice and understand systems thinking in relation to engineering content in particular units of study.

In the context of PRM, for e.g., to suggest that students must be able to accommodate, appreciate, identify and understand PRM contexts in terms of their social, environmental, ethical, safety, economical and commercial aspects, may be useful as a learning outcome. But this description does not specify clearly what is the process involved in achieving that outcome. It does not indicate the process of thought to be enacted so that the above aspects are duly considered.

In order for systems thinking to be practiced and understood in the study of PRM it becomes imperative to repurpose systems thinking as a process of thought. It is with this purpose in mind that in the present section I draw on literature beyond the confines of engineering education where systems thinking is construed as an epistemological process. By epistemological process, I mean how one comes to understand something about oneself and the world one inhabits.

The contemporary understanding of systems thinking is that it is one way of inquiring into the world and our relation to it (Bawden, 1991; Capra, 1997; Checkland, 1999; Churchman, 1968; Flood, 2001; Midgley, 2003). It is a way of making sense of the complexity of the world by framing and exploring complex situations in terms of wholes and relationships, instead of fragmenting it into parts and analysing each in isolation. This description of systems thinking, however, reflects a radical reconceptualization of the notion of a system.

Up till the 1970's systems theory conceived of a system as a conglomerate of distinct interacting parts. A system was considered to be something real and tangible, and it was

thought that its parts could be identified, manipulated and controlled in specific ways to achieve desired ends.

Accordingly, systems thinking was construed as a process of thinking wherein a complex situation could be examined as if it were a system constituted by identifiable, manipulable and controllable parts. It was further assumed that if the behaviour of these parts could be changed, then a similar behavioural change would come into effect in the entire system. In this way, the complex situation could not only be examined, but also controlled and manipulated for suitable purposes.

But this conception of systems thinking began to be challenged when it increasingly failed to generate insights to understand and improve complex real world social situations. These situations involved people and things interacting in complex and unpredictable ways, making it difficult to separate, identify and examine the situational system into distinct parts.

The success or failure of this situational system depended less on how the parts functioned, and more on how the interrelationships between people and things dynamically fluctuated in the course of interactions. These situational systems revealed their behaviours to be counter-intuitive, chaotic, unstable, dynamic, unpredictable, indeterminable and uncertain.

Consequently in the decades since the 1970's, systems theory, thinking, and practices matured to reflect an alternative, better informed perspective that privileges a focus where a complex social situational system can be understood in terms of interrelationships, interactions and emergence (Barton, et al., 2004; Bawden, 1991; Checkland, 1999; Flood, 1999; Jackson, 1991).

This perspective endorses the view that a system is an abstraction or intellectual construct to understand the complex social world and interactions within it (Checkland, 1999). Accordingly, systems thinking shifted its focus from thinking in terms of a system as if it were real, to thinking "systemically" in terms of interrelationships, interactions and their consequences. For the purpose of clarity this latter reconceptualised form of systems thinking is referred to (henceforth in this thesis as well) as systemic thinking (Bawden, 1991; Flood, 1999, 2001).

This reconceptualised notion of systemic thinking is underpinned by a fundamental revision of the systems idea. It emphasises a paradigmatic shift away from the notion of

a "system" to the notion of "systemicity" (characterised by features such as wholeness, interrelationships, interactions, and emergences).

This shift marks, what Flood (1990, p. 163) has characterised as a "switch in emphasis" where systemicity is metaphorically understood as a conceptual lens using which one can explore the complexity of real world social situations. Owing to this switch in emphasis, systemic thinking is seen as a "tool of an epistemological kind which can be used in a process of exploration within social reality" (Checkland, 1999, p. 249), as well as "methodology which orchestrates a process of learning" (Checkland, 1999, p. 279; 2003).

At this point, it is important to understand why systemic thinking ought to be understood as a learning methodology. The reasoning is as follows. Often any real-world situation is seen as complex and problematic by virtue of the fact that those who participate in it as well as those who observe it are likely to view it differently from one another. It leads various participants and observers to claim different sets of facts owing to their unique vantage points and ways of attending, valuing, and sense-making in relation to the particularities, opportunities, and problematic aspects of that situation (Clancey, 1997; Schön, 1987).

Accordingly, participants and observers of the said situation are likely to possess differing reasons as to why the situation is perceived complex and problematic. If the problematic nature of this situation is to be sensibly resolved and its apparent complexity is to be meaningfully understood, then it appears that systemic thinking is a useful learning methodology because its primary objective is to inquire about the perceptions and perspectives of those participants and observers which render the situation as complex and problematic in the first place (Bawden, 2010; Checkland, 1999; Flood, 2001).

There is, however, another important point to be foregrounded here about systemic thinking as a learning methodology. It is that by virtue of it being a methodology, systemic thinking is necessarily only a general, imprecise, and unambiguous "guide to action" (Checkland, 1999, p. 162).

It implies a finite of set of commitments made in the interest of thinking systemically about what makes any given situation complex and situation. It is not a method,

technique, or procedure, all of which imply "a precise specific programme of action which will produce a standard result" (Checkland, 1999, p. 162).

Bearing this in mind, the imperative then is to highlight what those methodological commitments might be for systemic thinking, so that they can be meaningfully applied to understand and act upon the problematics and complexity of real-world social situations.

Based on my understanding of the primary objective of systemic thinking as a learning methodology, I propose that to think systemically in and about a complex situation means a deliberate commitment toward:

1. Recognising, appreciating, and including multiple perspectives or viewpoints (which may be contradictory) so as to evaluate the beliefs and values that motivate them; and

2. Exercising critical self-reflexivity, social and ethical awareness when examining a situation.

These methodological commitments to systemic thinking are sufficiently general, imprecise, and unambiguous to be applicable even in PRM situations. In the following section, I shall discuss why the above commitments are the basis for the practice and understanding of systemic thinking as a competence at the classroom and unit level in PRM.

3.3   Understanding the Rationale of Commitments to Systemic Thinking in PRM

In the conclusion of the preceding section I proposed that two methodological commitments ought to be exercised in order to think systemically about the problematics and complexity of a real-world situation. In this section, I address why these commitments befit the purpose of thinking systemically in PRM situations.

Commitment 1: The first methodological commitment of recognising, appreciating, and including multiple perspectives or view-points so as to evaluate the beliefs and values that motivate them is particularly relevant to the practice of PRM. This is because literature on the practice of systemic thinking and PRM appear to crucially converge on the indisputable and unavoidable fact that we live in a pluralistic world.

Both practices recognise the existence and influence of multiple worldviews, values, and interests of actors in any social situation. For example, in the practice of systemic thinking there is an implicit recognition that people are centre-stage and that it is necessary to take into account their differing beliefs and purposes (Jackson, 2000). Problems, to which systemic thinking is applied, are not regarded as being purely technical. Rather they are sociotechnical in that all sorts of people may be involved or affected by the problems and want to participate in discussion and dialogue to resolve those problems.

A similar emphasis is found in the practice of PRM. It too is recognised as a sociotechnical practice (Cameron, 2005), wherein numerous people interested in resolving risk related problems – referred to as stakeholders – play a vital role in how risks are managed.

It is seen as essential to ensure that all affected groups have ample opportunities to participate in the management of risks, and that communication between all groups involved is effectively handled over the life cycle of the PRM process. This emphasis has emerged largely because of how risk is now construed in contemporary society. Risk, as a phenomenon as well as a concept, is widely accepted to be subjective in nature (Lewens, 2007; Wilkinson, 2010; Zinn, 2008).

People are likely to interpret it in different ways based on their beliefs, experiences, feelings, and attitudes, which together constitute the very worldviews that not only condition their perceptions of risk but also their actions in any social situation (Cameron, 2005; Fischhoff, 2012; Heyman, Shaw, Alaszewski, & Titterton, 2010; Jaeger, Renn, Rosa, & Webler, 2001; Lewens, 2007; Zinn, 2008).

Consequently, it is increasingly being recognised that risks are taken, run and imposed (Hansson, 2007; Lewens, 2007). In every PRM situation there are those who are exposed to the risk, those who decide to take, run or impose risks, and those who benefit or suffer unfairly from the said risks.

Such occurrences reinforce the observation that we live in a risk society, where human beings are increasingly responsible for the "manufacturing" of risks (Beck, 1992; Giddens, 2000). Risks are socially constructed (Heyman, et al., 2010; Jaeger, et al., 2001; Zinn, 2008).

Accordingly, in PRM, a risk situation is construed as being complex and problematic because various social actors in that situation tend to have varying worldviews and perspectives about what they perceive and understand as a risk. These worldviews and perspectives inevitably influence each actor's interactions, leading each to take, run or impose risks.

Both practices accept that diversity and difference are inevitable and inescapable aspects of social situations, and that these aspects must be appropriately acknowledged and responded to in order to manage the potential for conflict, contradiction, and power imbalance in those situations.

This is because it is now widely recognised that that differences, conflicts, and tensions between people tend to emerge in the presence of contradictory or incompatible worldviews and perspectives, while agreements often reflect a congruence and compatibility of worldviews and perspectives (Bawden, 2010; Flood, 1999).

Thus, the first commitment duly privileges the significance and influence of worldviews and perspectives. Appropriately managing a risk situation involves appropriately accessing and managing risk-related worldviews and perspectives.

Commitment 2: The second methodological is a corollary to the first commitment, and draws on the unique strength of systemic thinking in generating insights regarding complex and problematic situations.

The practice of systemic thinking situates its practitioner (a person who applies it to a situation to guide his or her action) at the heart of the practice. The practitioner is an integral actor in a particular situation since he or she possesses the capacity to change it for better or worse.

Consequently, the practitioner has to account for his or her own worldviews and perspectives. This step is crucial for three reasons. Firstly, it is well known that worldviews and perspectives majorly determine decisions, judgements, and actions (Bawden, 2010; Checkland, 1999; Churchman, 1968; Flood, 1999). Secondly, worldviews and perspectives are not only susceptible to distortions, but also strongly resistant to correction and change (DeWitt, 2010; Feyerabend, 1994; Mezirow & Associates, 2000). Thirdly, and most importantly, erroneous worldviews and perspectives have been shown to be the root cause of erroneous actions with catastrophic consequences (Bateson & Bateson, 2005).

Hence, numerous practitioners of systemic thinking overwhelmingly insist on the exercise of critical self-reflexivity, ethical and social awareness as a critical imperative of practical, ethical, and social significance (Checkland, 2012; Churchman, 1968; Flood, 2001; Midgley, 2000).

This commitment aligns strongly with the professional responsibilities of a process risk manager (henceforth referred to simply as a manager). The manager must think holistically about risks in relation to a variety of interrelated issues such as health, safety, environment, policies and regulations, and social and human factors.

He or she will need to exercise the powers of perception, investigation, and judgement in order to systemically understand and evaluate the risks in any given PRM situation (Jaeger, et al., 2001). The manager aims to ensure that risks in a PRM situation are not realised, and that the consequences (if the risks are realised) are appropriately mitigated (Cameron, 2005).

Being systemically minded, the manager is well aware that he or she is necessarily one of the social actors in that PRM situation. Like other social actors in that situation, he or she is also continually susceptible to inappropriate risk decisions and actions underpinned by erroneous worldviews (Cameron, 2005; Fischhoff, 2012; Sjöberg, 2007; Ward, 2001).

The second commitment comes into prominence in this context. In a PRM situation, the systemic commitment of being critically self-reflexive provides the manager an opportunity to examine the assumptions that underpin his or her own perception, understanding, and judgment involved in risk related decisions and actions. It affords an opportunity to avoid committing epistemological errors in risk perception which could potentially induce the realisation of new and unanticipated risks.

By being critically self-reflexive the manager sets up timely opportunities to examine the assumptions that underpin his or her perception, understanding, and judgment involved in risk related decisions and actions in that given PRM situation. It affords him or her opportunity to avoid committing epistemological errors in risk perception which could potentially induce the realisation of new and unanticipated risks.

A manager's responsibility also extends to the consideration of issues such as fairness, benefits and burdens of risks, as well as loss of amenities to affected individuals and

communities must be considered in risk thinking and decision-making (Cameron, 2005; Skelton, 1997). Such issues point to the socially constructed nature of risks.

In order to effectively execute his or her responsibilities the manager must be able to discern risk roles so that ethically and socially appropriate risk decisions and actions can be considered regarding the above issues. The second commitment comes into prominence here as well. Being systemically minded, he or she would be well aware that the above issues often emerge in a PRM situation since various actors interact as they do owing to diverse motives, values and interest.

Therefore, a manager's commitment to ethical alertness and social awareness would direct his or her attention on the examination of interrelationships and interactions of social actors, and emergences in a given PRM. It would enable him or her to discern how risk roles interact, what consequences result from such interactions, and how the relations and interactions may be better managed so that the above issues are duly responded to.

Implication of commitments for classroom practice of systemic thinking in PRM: PRM is a sociotechnical practice inherently founded on the strengths of the epistemological process of systemic thinking. It is regarded as a systems-oriented practice (Cameron, 2005). But this is not simply because it involves several complex industrial systems in interaction with one another.

It is because there is an unavoidable presence of social actors in the design, maintenance, operation, and interactions of these systems and the risks these systems and actors can impose. A manager must be able to think holistically about this social situation and also integrate broader social perspectives on issues like fairness, ethical distribution of benefits and burdens and so on.

Systemic thinking is readily applicable in a manager's thinking and decision-making in relation to the above social situation. The afore-mentioned methodological commitments enable a manager to orient his or her attention in a unique way. The commitments draw attention to the fact that such a social situation is complex and problematic by virtue of its socially constructed nature, and that a meaningful and productive way of resolving its complex and problematic nature is by privileging the need to examine and understand the worldviews and perspectives of various social

actors, which are known to majorly determine the decisions and actions of those actors in any PRM situation.

It is these worldviews and perspectives that motivate actors to interact in the ways they do, and so ultimately surface as the root cause of occurrences of risks being realised. A manager, committed to systemic thinking, would be convinced that appropriately managing a risk situation involves appropriately accessing and managing risk-related worldviews and actions. Exercising the two commitments would be a meaningful and productive way by which to generate vital insights to guide further action in that PRM situation.

It has been observed that PRM is frequently taught at university as if were a purely technical practice, even though it is widely recognised that its success depends on envisioning it as a sociotechnical practice (Cameron, 2005). For the present purposes, if systemic thinking must be promoted and developed in PRM, then it is imperative that its sociotechnical dimensions are heavily privileged.

Graduate chemical engineers enter process industries which are identified as sites of manufactured risks. Their actions, inactions, and inappropriate actions are likely to introduce or manufacture risks in such sites. A PRM educator who aims to promote and develop systemic thinking in a classroom must do so in a manner that enables students to first recognise human complicity in risk situations if they are expected to manage those kinds of situations in the near future.

To promote the practice and understanding of systemic thinking in a PRM classroom it is, therefore, imperative to privilege the epistemological process of systemic thinking and the practice of the above commitments. The need for systemic thinking and its practice is likely to become apparent to students when the socially constructed nature of risk-oriented interactions becomes obvious to them.

For this to happen, the students would need to be oriented towards the exercise of the above commitments. The first commitment would draw students' attention to the fact that multiple worldviews and perspectives do in deed populate a PRM situation, and that in order to develop a systemic understanding of that PRM situation, students need to consciously strive to bring multiple worldviews into the foreground. And the second commitment, a corollary of the first, would draw their attention to the fact that erroneous worldviews and perspectives can lead to erroneous risk-related actions with

catastrophic consequences. Therefore, it becomes perfectly meaningful and reasonable to exercise critical self-reflexivity, ethical and social awareness to identity and avert those kinds of instances.

Since both commitments privilege the need to meaningfully and mindfully manage worldviews and perspectives, the immediate pedagogic imperative would be to provide students with ample opportunities where they can recognise, appreciate, and evaluate individual and collective risk-related worldviews and perspectives as well as their influence on risk-related actions and consequences. It would imply the need to provide suitable PRM scenarios in the classroom where it is possible to meaningfully understand how various social actors enacting risk roles interact, what consequences result from such interactions, and how the relations and interactions between social actors may be better managed so as to reduce the likelihood of risks. Such opportunities would most likely promote the practice as well as understanding of systemic thinking in a PRM classroom.

3.4   Conclusion

In this chapter, I first examined how systems thinking has been understood and appropriated within the discipline of engineering education. I looked to pertinent literature on systems education in this discipline to ascertain that whilst systems thinking is widely acknowledged as a core engineering competence, the fuzziness of available definitions provide little direction for its promotion, practice and understanding at classroom and unit level in chemical engineering.

My response to this was to direct my attention toward systems thinking as it has been understood in areas beyond engineering education. I have drawn on the writings of various systems thinkers in order to propose the notion of 'systemic thinking' as an epistemic competence with specific commitments that a person enacts while staying true to the core philosophical idea of systems thinking. By drawing on literature on societal risk and safety theory and practices I then situate systemic thinking as the epistemic competence that underpins risk thinking in PRM situations.

I have proposed that in order for systemic thinking to be practiced and understood in a PRM classroom, students must be provided the opportunity to enact two methodological commitments in relation to a given PRM situation. These are:

1. Recognising, appreciating, and including multiple perspectives or viewpoints (which may be contradictory) so as to evaluate the beliefs and values that motivate them.

2. Exercising critical self-reflexivity, social and ethical awareness when examining a situation.

4   Implementing Systems Thinking in Process Risk Management

In the preceding chapter I addressed my inquiry's first guiding question: How can systems thinking be construed in the study of PRM situations? I pointed out that systems thinking needs to be construed differently to the way it is currently understood in engineering education literature.

I argued that if it is to be engaged and developed by students in their study of PRM situations then it ought to be construed as an epistemic competence which students would need to practice while thinking about any given PRM situation. I recommended that this epistemic competence be explicitly referred to as *systemic thinking*, as a way to clearly delineate the conceptual shift involved in exercising two interrelated methodological commitments.

I proposed that systemically thinking about any given PRM situation meant: (1) recognising, appreciating, and including multiple perspectives or viewpoints (which may be contradictory) so as to evaluate the beliefs and values that motivate them, and (2) exercising critical self-reflexivity, social and ethical awareness when examining a PRM situation. I provided the rationale for each of these methodological commitments and argued that when students practice these commitments they will be thinking in similar ways to professional process risk managers.

In the present chapter, I extend my argument further by addressing my next guiding question: How can systems thinking be implemented in the study of PRM situations? My focus here is specifically on exploring and identifying the nature of pedagogic and assessment practices needed to encourage students to think systemically while examining PRM situations.

I begin by examining the educational commitments involved in competence development. This is because teaching, learning, and assessing any competence is radically different from teaching, learning, and assessing conceptual content. The development of a competence for professional engineering practice requires a reconceptualization of both the process of education and the role of the educator in it.

I show that a different set of responsibilities must be undertaken by all who are directly involved in the competence development enterprise. Thereupon, I explore the kind of learning activities that are likely to invoke students' ability to think systemically in PRM

situation. I argue that these activities are likely to stimulate systemic thinking only when the underlying emphasis of both pedagogic and assessment practice is on epistemic development.

4.1 Principles of Learning involved in Competence Development

For the purpose of this inquiry, I have drawn on a situative, sociocultural, process-oriented view of formal educational competence development. By adopting this view, I have committed to understanding learning and the process of competence development in a unique way:

Learning as a situative phenomenon: The situative perspective of learning currently dominates the field of learning sciences (Johri & Olds, 2011). According to Lave and Wenger (1991), all learning can be considered to be situated in the sense that it takes place in a specific situation or context that codetermines both the learning process and its outcome. In this perspective, knowledge is understood as distributed among people and their environments, including objects, artefacts, tools, books, and the communities of which they are a part (Greeno, Collins, & Resnick, 1996). Furthermore, as Greeno et al. characterise it, learning by a group or individual involves becoming attuned to constraints and affordances of material and social systems with which they interact. This happens chiefly when the group or individual participate in the practices of the community of which they are members, and begin to develop an awareness of the facilitative and inhibitive patterns that organise the group's activities and the participation of individuals who are attuned to those patterns.

When this view is applied in the context of chemical engineering risk management education, it implies that students (a learning community of those enrolled in this unit) learn about risk management practices by modelling these practices in a classroom setting. In thinking deliberately about authentic risk situations with the aid of theories and practices of risk management, they can genuinely appreciate the practices of risk managers and their underpinning rationales.

Learning as an emergent phenomenon: The contextual nature of a particular situation, and the group or individual's degree of attunement to its constraints and affordances directly affects what and how the group or individual learns. In order to appreciate and understand the emergent character of learning, it is necessary to first recognise that knowledge itself is emergent, as in, emerging from the interaction between a knower

and his or her environment (Davis & Sumara, 2006; Fenwick, Edwards, & Sawchuk, 2011; Morrison, 2008; Osberg, Biesta, & Cilliers, 2008). In this interaction, every transaction between the knower and environment sets up a new relationship between knowledge and action, leading to new knowledge that changes the environment and the knower, consequently causing the knower to act differently. In effect, this is how a knower learns continually, and learning emerges from and builds on each previous transaction.

Learning as a constructive-developmental phenomenon oriented toward meaning making and understanding: The transactional account of a knower interacting with the environment leads to the argument that learning can be understood as a continuous process through which knower and knowledge are simultaneously redefined in relation to one another (Davis & Sumara, 2006). Specifically, the knower's cognitive faculty engages in a process of "organizing and re-organizing one's subjective world of experience, involving the simultaneous revision, reorganization, and re-interpretation of past, present, and projected actions and conceptions" (Davis & Sumara, 1997, p. 109). However, as Sankey (2007) adds, it is also an existential process of understanding guided by the need for clarity, consistency and coherence, heavily influenced by the knower's environment, experience, culture and language.

Similarly, Allen (2001) has noted that the process represents an exercise in internal sense making whereby experiences, conjectures, and experiments are continually modified to develop suitable productive and meaningful personal interpretive frameworks. What we consider as 'knowledge' can be alternatively considered to be a meaningful interpretive framework constructed by a knower attempting to develop a clear, consistent, and coherent network of ideas, concepts and information so as to understand better than one did before (Cilliers, 2002; Sumara & Davis, 1997).

The above process of learning is 'constructive' because a knower actively builds or constructs his or her knowledge and other capacities, and what is learned is stored in some psychological 'structures', patterns, or schemes in the brain and central nervous system in a personally meaningful manner for easy retrieval when necessary (Davis & Sumara, 2006; Illeris, 2011b). Mezirow (2000, 2009) posits that the psychological structures are in fact, structures of meaning, or 'frames of reference' as he calls them. According to him, they are structures of culture and language through which we construe meaning by attributing coherence and significance to our experience; structures of assumptions and expectations through which we filter sense impressions,

selectively shape and delimit our perception, cognition and feelings so as to predispose our intentions, beliefs, expectations and purposes and setting up specific lines of action. They give rise to preconceptions, which once set or programmed automatically mobilize us from one specific mental or behavioural activity to another, and at the same time generates resistances that "reject ideas that fail to fit our preconceptions" (Mezirow, 2009, p. 92).

The constructive approach highlights a process of transformation in which, as argued by Mezirow (2000, 2009), it is the learner's meaning structures that are being transformed. Alternatively, as argued by Wenger (1998, 2009), this transformation is more a process of meaning negotiation, one which is "at once both historical and dynamic, contextual and unique" and "entails both interpretation and action" (Wenger, 1998, pp. 53-54). However we choose to think of learning, whether one thinks of transformation or negotiation, what is central to note here is the role of meaning making. Equally important is the recognition of the fact that there is a change in meaning structures when one learns. From a psychological point of view, as Kegan (2000, 2009) has argued, the constructivist perspective of learning leads to an epistemological change. This implies that not only do we form meanings and change them; we "change the very form by which we are making our meanings. We change our epistemologies" (Kegan, 2000, p. 53).

However, research in the area of learning psychology has revealed that while learning is arguably a change in one's ways of knowing, these very ways of knowing evolve over an individual life span (Baxter Magolda, 2006; Kegan, 2009; King & Kitchener, 2004; W. S. Moore, 2002; West, 2004). The studies cited above serve to significantly emphasise that learning is not only a constructive process oriented toward meaning making and understanding, it is equally a developmental process as well. It is particularly important to bear in mind that, as Kegan's (1982, 1994, 2000) studies have shown, complex capabilities strongly associated with adulthood – being able to think abstractly, to construct values and ideals, introspect, subordinate short-term interests to the welfare of a relationship and orient to and identify with expectations of groups and individual relationships of which one wishes to feel a part – ordinarily take two decades of living to develop or even longer for some individuals.

Competence development as an advanced constructive-developmental learning phenomenon: All of the previously stated assumptions play a vital role when it comes to

learning any competency. This is strongly grounded upon significant insights from competency research conducted in diverse areas, where both "the concept of competence and the practice of competence development have been studied and analysed from very different angles and in very different contexts" (Illeris, 2009d, p. 2). Watkins and Cseh (2009) point out that in the history of competence development, the very focus and scope of what a competence is in a definitional sense has undergone an evolution, first from minute behaviours, then to patterns of behaviour, to now global mindsets, thus urging us toward a broader conception of competence as wilful capacity or ability grounded in deliberate intent. This is fairly evident in the typical and generally accepted definition of competence as "the ability to successfully meet complex demands in a particular context through the mobilization of psychological prerequisites (including both cognitive and noncognitive aspects)" (Rychen & Salganik, 2003, p. 43).

However, in addition to intention and capacity, competence also involves "the potential to deal appropriately with future and unforeseen situations" (Illeris, 2011a, p. 49). In fact, Illeris (2011c), drawing on the research of several researchers, argues that these three aspects of competence give rise to some of the most important qualities of a competences. First, competences relates to the application of ability or capacity in specific situations, thus implying that competences are situative and contextual. Second, competences have the nature of potentials, that is to say they can be further developed or deployed in future unknown and unpredictable situations. This strongly suggests that competences have an emergent character. Third, competences include insight, empathy and structural understanding. Given the previous two qualities, a competent person cannot act competently unless he or she was able to draw deliberately and consciously upon personal intellectual and emotional reserves as well as social resources. As Illeris points out, the ability to react frankly and at the same time critically to new trends and changes that constantly arise and demand a reaction implies quite extensive demands for flexible insight and empathy in relation to the reality in which it is to be displayed. In this regard, competences are strongly associated with a person's constructive or meaning making capacities.

Fourth and closely related to a person's constructive capacities, competences involve judgements and making decisions. Following from the earlier point, one can easily recognise that any display of competence in relation to the continuously evolving situations requires the ability to "decode what is at stake, judge its impact and make relevant and workable decisions about what to do, and all of this often has to be done

immediately and under time pressure" (Illeris, 2011c, p. 52). Such situations demand, what are known as judgements-in-contexts (Beckett, 2009), drawing upon a person's ability to develop an inferential understanding of a given situation. However, as Illeris (2011c) has pointed out, this process is not entirely cognitive, emotions are involved as well to invoke empathy and intuition, and both cognitive and emotional elements will nearly always be actively combined in the immediacy and urgency that entail judgements and decision making in unexpected and unforeseen situations that challenge one's competence.

And lastly, competences are not commodities to be acquired; instead they "must be developed in and by a person" (Illeris, 2009a, p. 85), and that they can be developed only if a person is keenly and positively interested in those competences and is attitudinally committed to developing them. In order to appreciate the significance of this point it is necessary to recognise the performative and experiential aspect of competences. A person is said to be competent at something if he or she responds appropriately in a specific situation, thus highlighting a relation between competence and the wilful capacity to perform a specific action. It is in this sense, that a competence is performative. However, the same instance demonstrates that the person was able to judge that that particular situation required a very specific response. This ability to discern appropriately what kind of response is required in one situation as compared to another can only be attained through diverse experiences where a similar response may have succeeded or failed in the past. It is in this sense that a competence is experiential.

The developmental character of competence emerges out of the essential tension between competence and experience, as every experience imparts valuable lessons that transform one's competence and vice versa (Wenger, 1998, pp. 137-139), provided, of course, that a person is both attuned to such experiential lessons and keen to mindfully reflect upon the lessons to improve one's competency. Owing to this consideration, Gadotti (2009) insists that we conceptualise competency development as the teaching-learning process that can nurture an individual's competency through practice, that is to say, a competency is learned by putting it in practice.

Competence development as complex learning phenomena: According to the principles stated above, competence is construed as a situative, emergent, constructive, developmental, performative, and experiential ability, and, in turn, that learning a competency involves each of the above aspects. However, these very aspects also lead

to one final interesting feature, which when accounted leads to a holistic view of what it means to learn a competency. To introduce this feature the issue concerning learning as a general phenomenon is addressed first, followed by the issue as it relates to learning a competency.

Learning is no longer understood to be simply acquisition of knowledge and skills. Contemporary understanding of learning, based on wide ranging research in learning sciences, conceptualises it more broadly to include emotional, social and societal dimensions and is characterized by complexity (Bransford, Brown, & Cocking, 2002; Illeris, 2009c; Johri & Olds, 2011). These dimensions interact and impact one another to give rise to the complexity inherent in the situative perspective of learning. Johri and Olds (2011), for instance, point out that the social and material context of a learning situations, the activities and interactions occurring within it, and participation and identify of participants constitute a complex web of social organization and the environment which individuals are contextually part of largely determines what individuals conceive knowing to be and consequently how they learn.

The relationship between environment and individual and how each co-determines the other provides an insight into the role of complexity in what and how the individual learns. Implicit in this relational view of learning is the fact that the cognizing individual is always contextually situated as a part of an environment and hence, is an integral part of a larger relational fabric. What is being cognized or learned by an individual from moment to moment "depends upon the interplay of setting, culture, participants and era" (Davis, Sumara, & Kieren, 1996, p. 166). Setting, culture, participants, and era, in a sense, become initial conditions that deeply affect an individual's states of knowing, i.e. what an individual comes to know and how the individuals acts and interacts with a dynamic and responsive world. Even minute changes or differences in these initial conditions are likely to produce dramatically different states of knowing. And since, as argued earlier, learning can be characterised as change in one's ways of knowing (see previous subsection – learning as a constructive-developmental phenomenon, pp. 4-5), this implies the possibility of dramatic changes in what and how it is learned.

The learning involved in competence development is similarly complex. According to Illeris' process theory of competence development (2009a, 2009b, 2011c), this complexity can be explained to emerge from the interplay of two processes. One that involves the external interaction between the person and his or her social, cultural and

material environment, and is characteristically historical, geographical, societal, and time and place dependent; and the other is the internal psychological process of elaboration and acquisition, wherein impulses and impressions of the interaction process connect with results of prior learning to form new learning outcomes. It is here that individual and developmental differences seem to produce the greatest variations in what is learned, even in the presence of the same environmental impulses.

These two processes are defined by three dimensions, namely interaction, content and incentive. Interaction directly refers to the above mentioned external interaction process. Content and incentive represent the two equal dimensions that interplay in the above mentioned internal psychological process, with the former concerned with the function of managing the learning content while the latter provides and directs the necessary mental energy that runs the process of learning. Learning anything involves learning something in particular, and thus there is always a learning content, but an incentive is also always present such that its strength and nature decidedly influence the strength and nature of learning. Stronger the incentive and greater the engagement with the learning content, then stronger the learning outcome will be. All three dimensions however are necessarily interdependent. Content and incentive are always initiated by impulses from the external interaction process and then integrated into the internal psychological process of elaboration and acquisition. Similarly, the process of interaction necessarily culminates only in the presence of the other two dimensions.

Each of the three dimensions provides a certain quality based on their function. The content dimension fosters the construction of meaning and the ability to deal with the challenges of practical life, resulting in an overall quality of personal *functionality*. The incentive dimension which includes such elements as feelings, emotions, motivation, and volition, dispenses and directs the mental energy for learning to occur. Thus, it secures a continuous mental balance and results in the development of personal *sensitivity*. The interaction dimension provides the impulses that initiate the learning process, which may be in the form of perception, transmission, imitation, experience, activity, participation and so on. It serves the personal integration in communities and society and thereby also builds up the *sociality* of the learner. In relation to competence development, functionality, sensitivity, and sociality constitute the basic qualities that affect the learning process involved in becoming competent such that the quality and strength of learning in competence development is directly dependent on the strength of each of those basic qualities.

All three qualities and their corresponding dimensions must be involved with considerable weight in whatever competence is to be developed. Ultimately, according to Illeris' learning theory, competence development is assumed to be a complex learning phenomenon that includes social interaction and individual psychological processing. In addition, rational and emotional elements are equally present, owing to which competence development can be obstructed, hindered, or affected by psychological phenomena such as personal barriers, distortions, defences, resistances and so on which can play an important role in the learning process.

4.2 Implications of Principles of Learning for Educational Competence Development Practice

Firstly, it must be acknowledged that competence is contemporaneously understood as a holistic phenomenon wherein knowledge, skill, commitment, and attitude are enfolded together into a complex mix to constitute ability grounded in intent (Beckett, 2009; Gadotti, 2009; Watkins & Cseh, 2009).

Consequently, competence development is understood as a holistic process as well, wherein the qualities of functionality, sensitivity, and sociality as described above must be involved and developed together in relation to the chosen competence. Secondly, in this section attention is drawn to competence development specifically in and through formal educational institutions, as distinct from workplace competence development practices and strategies (Ellström & Kock, 2009).

The previous section focused on making explicit a set of principles about competence development that provide an insight into what it means to learn a competency. These principles provide the conceptual bedrock upon which the educational practices for competence development in risk management are founded. Given that these principles represent a set of fundamental assumptions about the learning process underpinning competence development, it is imperative that their implications are identified and accounted in the ongoing discussion. Hence, in this section, the implications flowing from the previously stated principles are discussed in relation to the roles of the learner, the educator, and the design of the learning space for competence development.

Role and significance of Learner: The learner takes centre stage in the learning that underpins competence development as conceptualised in this thesis. This learner-centred emphasis issues directly from the supposition of the situative, emergent and

constructive nature of knowing and learning. In the learner-centred perspective, it becomes a learner's prerogative to 'develop' his or her own competence through the educational experiences designed for that purpose.

Although the social aspect of learning has a significant influence on learning, ultimately and undeniably what is learned (whether it be disciplinary content, professional competences or both) and how well that is learned depend on the learner. This is because learning cannot eventuate and culminate in the absence of the internal psychological process involved. Furthermore, given that that process is in turn the result of ongoing transactions between the content and incentive dimensions, the significance of the influence of the learner's attitude, interest, motivation, volition, and other affective aspects on learning is all the more heightened.

Therefore, as Illeris (2009a, 2011c) has argued, while competences are innately presently in all of us, their development in particular is significantly a matter of commitment, positive interest and attitude on the part of the learner. Just as competence, as conceptualised in this thesis, must be developed in and by the person, it can be similarly reasoned that success in educational competence development hinges on an active learner.

Role and significance of Educator: When the learner takes centre stage in educational competence development, the educator takes on a supporting role in the learning process. This shift issues directly from insights that invite us to reconceptualise the relationship between teaching and learning when the process of learning is considered situative, emergent, constructive, and developmental in character.

To begin with, we must acknowledge, like Boshier and Huang (2008) have, that the existence of important forms of learning that occur beyond the gaze of teachers serves to suggest that all teaching does not involve learning. Although teaching and learning are arguably enfolded into one another, the relationship between the two is altogether non-causal (Boshier & Huang, 2008; Edwards, 2006). Wenger (1998), for example, draws our attention to this point when he observes that what ends up being learned may or may not be what was taught, or more generally what was intended. People learn what they want to learn and in different ways (Bryan & Clegg, 2006). This observation is strongly consistent with research on learning outcomes, learning and assessments, learning professional skills and competence development (Haggis, 2009; Hussey & Smith, 2008; Redish & Smith, 2008; Walther, et al., 2011)

Consequently, it has been argued that this relational imbalance also points to the uncertainty and unpredictability inherent in every pedagogic encounter. All the contributing factors of that situation are so intricately, ecologically, and complexly related that it is unwise to establish any causality between teaching and learning (Davis & Sumara, 2006). Instead, it is far wiser to understand learning as emerging "through a complex interplay of experiences, relationships and ideas being worked and reworked through the process of reflection" (Phelps, 2005, p. 41).

The recognition and appreciation of the emergent nature of the process of learning consequently leads to an alternative conception of the role and responsibility of the educator. Accordingly, for Wenger (1998), instruction is no longer seen to cause learning, instead it creates a context in which learning can occur. This marks a shift from 'instruction for learning' toward 'facilitation of learning'. Morrison (2008) has describes it as a move from the role of expert and transmitter of knowledge to facilitator, co-learner and co-constructor of meaning, enabling learners to connect new knowledge to existing knowledge. A facilitator is charged with the responsibility of affording "occasions that [are] rich with learning possibilities and in which we might participate with students in the unfolding of understandings" (Davis & Sumara, 1997, p. 115). In fact, Wenger (1998) contends that facilitation aims to be opportunistic in the sense that the planned and emergent aspects of pedagogic interactions can become structuring resources for each other.

Essentially, it falls to the educator to create the conditions that foster emergent learning, by promoting pedagogic encounters that emphasise interaction, decentralized control, diversity, redundancy, and feedback (Davis & Sumara, 2006; Morrison, 2008). This applies to educational competence development as well, for as Illeris (2009a) has noted, it is the educator's responsibility to help learners to gradually take responsibility for themselves and to join the participatory and decision making activities and processes that constitute competence development in a classroom setting. Thus classroom facilitation of competence development is viewed as a "task of orchestrating a complex environment of learners and activities" (Shuell, 1996, p. 743).

Design of the Learning Environment or Learning Space: Illeris (2009a) identifies this to be the most decisive factor and the most challenging task for educational competence development. This emphasis on the design of learning environment arises from the fundamental assumption of the situative perspective of knowing and learning that the

environment significantly impacts and influences an individual's conception of knowing and how they learn (Johri & Olds, 2011). The environmental focus attends to the inclusion of the learning context and its crucial role in the learning process. Research in the area of social and situated cognition reveals that learning is contextual in the sense that what we come to know depends upon our action and interaction with a dynamic and responsive world, which as previously stated can be characterised as the interplay of setting, culture, participants and era (Davis & Sumara, 2006; Lave & Wenger, 1991; Rogoff, 2003).

Accordingly in a classroom setting, the above ecological view of learning prompts us to consider that, learners and the educator are together a part of an ever evolving learning context, where learners and the educator are both changing themselves and others through their interaction while the context is simultaneously changing and evolving as well (Davis & Sumara, 1997).

However, we must also always remember that in the ecological learning perspective what is learned and how it is learned is largely attributed to the degree of attunement of each learner to his or her learning situation (Greeno, et al., 1996). In fact, as Shuell (1996) has argued it is the learner's goals and expectations, which in turn condition his or her psychological response to the learning situation, that ultimately determine the learning outcome not the goals and expectations of the educator. Furthermore, Shuell insists that in a classroom the educator is always just a part of the psychological and social context that affects what the learner learns, and his or her effect on the learner is limited by a variety of factors. These factors include the developmental level and prior knowledge of the students, the cultural context in which the facilitation occurs, the specific content being learned, and the academic goals being pursued. In a sense, the educator's role pales in significance compared to the influence of other factors. Significantly, this point foregrounds the complexity of classroom learning while simultaneously tempering any exaggerated expectations that an educator may espouse about learning in such a setting. The educator is not solely responsible for learning; responsibility is shared by all involved in that process and distributed across the entire learning collective in that setting.

While it is clear that the onus of designing a suitable learning environment for educational competence development rests decidedly on the educator (Adams, et al., 2011; Gattie, Kellam, Schramski, & Walther, 2011; Illeris, 2009a; Johri & Olds, 2011;

Litzinger, et al., 2011; Walther, et al., 2011), the complexity of classroom learning, the possible differences in degree of attunement of individual learners depending on their own goals and expectations, and the unpredictability and uncertainty inherent in the complex learning processes involved in competence development make this endeavour extremely challenging; a task to be mindfully and enthusiastically approached, but with tempered optimism. Educational competence development must be unhurried and nudged forward rather than pushed. It must "make room for engagement and participation of those who are to develop their competence" (Illeris, 2009a, p. 98).

In this thesis since competence is conceived and conveyed as a holistic concept, correspondingly the challenge of educational competence development also takes a holistic approach. Hence recommendations for the design of an effective learning environment for educational competence development have been adapted from the How People Learn framework (Bransford, et al., 2002). It proposes a learning environment with multiple interlinked foci. This offers a systemic view wherein effective and meaningful educational competence development emerges when the following multiple yet interrelated foci interact, as shown below:

- **Develop a learner-centred environmental focus.** This recommendation is in accordance with the central role of a learner in the process of educational competence development as highlighted earlier. It becomes the educator's responsibility to devise and implement activities and tasks appropriate to the development of the desired competence bearing in mind the current knowledge, skills, and attitudes of the learners, and to elicit active participation and engagement of all learners involved.

  Since in this case the competence to be developed is a particular kind of thinking, the educator will need to actively inquire into students' thinking and get students to examine preconceptions, differences and patterns of thoughts. The pedagogic prerogative is to facilitate active learning, encouraging learners to engage in action and reflection particularly since it is widely accepted that critical reflection is central to effective action (Boud & Falchikov, 2006).

- **Develop a knowledge-centred environmental focus.** This recommendation places the disciplinary content as the focal zone in and around which crucial disciplinary competences can be practiced by the learners. It is based on the previously stated notion that competence is always integrally related the content dimension.

Since in this case the competence to be developed is a particular kind of thinking, namely systemic thinking, the implication is that in order for learners to develop this ability in chemical engineering risk management, they must not only know how to think systemically but also understand how relevant risk management theory and practices can be productively applied to think systemically in authentic risk situations.

- **Develop an assessment-centred environmental focus.** This recommendation acknowledges that competence is developed through practice, and that practice opportunities provide experiences essential for the learner to get a feel for the competence to be developed. Since competence is a practical ability to respond to particular situations in particular ways, the performative aspect is paramount. Consequently educational competence development must necessarily incorporate this performative aspect as well. However, given that each new experience builds on the previous one, and one learns from the failure or success of each experience, educational competence development must also be seen as being formative. With this in mind assessment for educational competence development is formative in nature.

Since the learners in this case are to develop the ability to think systemically in risk management situations, the educator is charged with yet another prerogative: to design and implement such assessments that demand the use of systemic thinking and make patterns of thought visible to both the educator and learners involved so that these can be examined and rectified accordingly through regular and ongoing feedback. It must be stressed, however, that this emphasis on formative assessment and feedback is not restricted to educational competence development alone. It is very much in agreement with contemporary recommendations of educational literature in general which recognises the impact and influence of assessment on both teaching and learning (Wiliam, 2010).

Following Duch and Groh (2001), in this instance for the development of systemic thinking in chemical engineering risk management, assessments are treated as learning occasions that provide a very natural opportunity to practice and demonstrate both disciplinary content knowledge and disciplinary competence together in an integrated manner. In addition, it must also be pointed out that feedback is positioned as advice rather than instruction since the educational aim is to foster ownership of learning by the learners who are to

develop their competence (Price, Handley, & Millar, 2011). This strategy directly links to the fact that competences, as understood and conveyed in this thesis, must be developed in and by the learners themselves and hinges on their personal commitment to this goal. Accordingly, peer and group based dialogic feedback processes have been chosen as effective and valuable means to enrich the learning experience (Gibbs, 2006; A. M. Rae & Cochrane, 2008).

- **Develop a community-centred environmental focus.** This recommendation is underpinned by the appreciation of the fact that competence development has a significant social dimension. We must remember that competence is a practical ability to respond in a specific way often deemed appropriate by a community of practitioners. For example, a process risk manager is said to be competent when he or she is able to respond appropriately to diverse risk situations in a manner similar to other conscientious risk managers, drawing on the relevant theories and practices of the process risk management community. Seen from a competence development perspective, a process risk manager develops his or her competence in relation to the practices of such a community. The example above emphasises that competences are learned , practiced, developed and refined through communal ways, by interaction, negotiation, and cooperation between members of a community of practice (Lave & Wenger, 1991; Wenger, 1998).

  Similarly, educational competence development can also be viewed such that specific competences are developed in a communal way in a classroom setting, through activities that promote interaction, negotiation, cooperation and collaboration. The educator is responsible for facilitating a supportive, meaningful and respectful learning environment in which learners and educator together form a cooperative, collaborative, and non-competitive learning community to develop a desired competency.

  In this case, since the target competency is a specific way of thinking, the pedagogic prerogative is to foster community learning through group work opportunities whereby learners can collectively evaluate reasoning, notice and examine differences and patterns of thoughts, question underlying assumptions, and learn how to interact with different people and ideas and when to rely on advice and knowledge, and experience ontological, epistemological and methodological dilemmas which can prompt deeper and deliberate thinking (Cullen & Harris, 2009; Jonassen et al., 2009; Jonassen, Strobel, & Lee, 2006;

Saltmarsh & Saltmarsh, 2008). Such an environmental focus promises to promote the kind of intellectual camaraderie and attitude toward learning essential to build a sense of community in which the mix of cooperation and argumentation is likely to enhance cognitive, conative and affective development (Bransford, et al., 2002; Istance & Dumont, 2010).

4.3 Activities and Interactions to Develop Systemic Thinking in Process Risk Management

In this thesis, an important premise of educational competence development is that learning emerges from what the learners and educators together do within their immediate learning environment that is likely to lead to the development of competences. It is an activity-based perspective to promote learning of competences, and activities become essential to the context in which learning occurs. Such a view emerges as a direct result of adopting the situated view of learning wherein knowledge is fundamentally taken to be developed in and through activity (Clancey, 1997; Lave, 2009; Lave & Wenger, 1991; Wenger, 1998). However, as Clancey (1997) has argued, activities also necessarily imply interactions as well. According to him, an activity is a "participation framework, an encompassing fabric of ways of interacting that shapes what people do" (Clancey, 1997, p. 266), and informs their mode of engagement with other people and things in the environment. Hence, based on the above rationale, in this section we specifically address what kind of activities and interactions are likely to lead to learning and development of the ability to think systemically in chemical engineering risk management.

Developing epistemic competence for thinking systemically about process risk: Before we can identify specific learning activities and interactions, it is imperative to understand what really ought to be developed when we talk about developing the ability to think systemically in PRM. To do so, however, we need to revisit and explore in further detail points made in the previous chapter (Chapter 3).

Instead of taking a purely technical approach to PRM, a systems oriented process risk manager would undertake a relational approach. This approach would be integrative and inclusive, and would incorporate a much broader perspective than a purely technical one, sweeping in multiple perspectives such as safety, health, and planning,

governmental administration and also includes financial, social and human factors (Cameron, 2005).

With this in mind, in the previous chapter (Chapter 3), I argued that systemically thinking about any given PRM situation meant: (1) recognising, appreciating, and including multiple perspectives or viewpoints (which may be contradictory) so as to evaluate the beliefs and values that motivate them, and (2) exercising critical self-reflexivity, social and ethical awareness when examining a PRM situation.

It is important to note here that these commitments have been conceptualised as the actions of a competent process risk manager who is able to apply these commitments as a means to think systemically in natural or social risk situations. A deliberate yet subtle distinction is being made to highlight commitments as actions, rather than activities. From a situative perspective, it is necessary to recognise that an activity provides the context within which actions are taken in pursuit of particular goals or aims. Put another way, actions are commitments put into practice in order to undertake a specific activity. This distinction is vital to our understanding of educational competence development. Insofar as we have discussed in this chapter, a competence can be developed in an educational setting through the practice of that competence. This implies engaging in activities that require the learner to put certain commitments into practice. Hence, development of the ability to think systemically in chemical engineering risk management means putting the above commitments into practice.

There is, however, a crucial corollary which must also be emphasised. Given the developmental nature of competence, what needs to be crucially borne in mind by an educator is that getting learners to put those commitments into practice is not simply a matter of doing them; rather it is about effecting subtle epistemic development of learners through such practices. According to Bawden, a systems educator with several decades of experience in systemic practice and systems pedagogy, strongly advocates the fact that when it comes to the development of systemic competencies, the emphasis is first and foremost on the epistemic development (Bawden, 2005, 2010).

Developing contextualising sensibility and epistemic flexibility, essential pre-requisites of epistemic development to think systemically about process risk: The emphasis on epistemic development, as recommended above by Bawden, however, is significantly based on the pioneering research of Salner (1986), noted to have been the first researcher to link stages of adult development to epistemological positions and to show

the relevance of epistemological positions to the development of systemic competences
. Crucially, Salner (1986) has argued that systemic competences cannot be adequately acquired by students until their thinking has reached a particular developmental level and they have integrated particular epistemological assumptions into their overall worldviews. She drew significantly on Perry's (1968) epistemological development scheme, Kitchener's (1983) three-level cognitive processing model, and insights from epistemological debates in the philosophy of science to point out not only that genuine systemic competence is exhibited by a person with a strong contextualising sensibility and flexibility in epistemic strategies, but also, conversely and more importantly, that the development of both contextual sensibility and epistemic flexibility are essential pre-requisites for the development of the ability to think systemically.

Following Perry (1968), Salner describes contextualising sensibility as the ability, developed as a result of intellectual and ethical maturity, to recognise the important of context and choice in defining truth and value and that knowledge is constructed through the examination of contexts. From a situated cognition and activity perspective, this sensibility is seen as a person's ability to attune to the constraints and affordances of a situation through his or her participation in that situation (Greeno, et al., 1996; Norman, 1999). This sensibility is vital to systemic practice (i.e. applying systemic thinking to the formulation and resolution of a complex, ill-structured, and problematic everyday situation) precisely because "ignoring real-word contexts increases the risk of failing to capture relevant information in analyses and at the risk of solving non-existent problems" (Medin & Thau, 1992, p. 167). Also, following Kitchener (1983), Salner describes epistemic flexibility as the ability, simultaneously emerging alongside contextual sensitivity and awareness of the constructive nature of knowledge, to recognise the need for a critical and evaluative stance when making one's inquiries and to possess the courage and means to act accordingly. In order to truly understand and appreciate the need and significance of epistemic flexibility for systemic practice and its role in the development of systemic thinking, we must necessarily venture into the following discussion regarding the role what Kitchener terms epistemic cognition and its relational significance to the formulation and resolution of complex, ill-structured, and problematic situations.

Relation between epistemic cognition, complex ill-structured problems and their formulation and resolution using a systems approach: Kitchener (1983) sought to understand and explain how adults make wise and thoughtful decisions about difficult

problems. More specifically, she wanted to understand and explain how adults monitor their problem solving when they are engaged in the complex decision making of everyday life. Kitchener drew on the work of Churchman (1970), who had analysed different models of inquiry, the structure of the problems each might address, and under what conditions each might be solved. Churchman's work allowed Kitchener to characterize the problems that were central to her research as being 'ill-structured', those encountered most often in the real world, to which there is no single unequivocal solution which can be effectively determined at a particular moment by merely applying a particular decision making procedure. Churchman, a renowned philosopher of systems and management and well-regarded systems theorist and scholar, actively advocated the systems approach as the most effective and ethical means for resolution of real world problems which are ill-structured in nature (Churchman, 1968).

Ill-structured problems can be conceptualized in multiple ways, with multiple potentially valid solutions. In fact, problems are deemed ill-structured not simply owing to constraints and lack or overload of information, but also because of differences in conceptualisation by different people with different backgrounds, differing perceptual acuities toward the constraints and affordances of the situation, claiming different sets of facts based on their unique ways of attending, valuing and sense-making in relation to the particularities, opportunities and problematic aspects of the situation they are in (Clancey, 1997; Schön, 1987). The dilemma posed for the problem solver is to decide which conceptualization, each with its own set of epistemological assumptions, and solution to pursue.

Churchman's systems approach is holistic in the sense that it seeks to synthesise a solution by reframing as many perspectives as possible in a way that generated a resolution which is ethically defensible. As noted by Kitchener (1983), following Churchman and others (Rescher, 1976; Toulmin, Reike, & Janik, 1979), since evidence, expert opinion, reason and argument are available for each of the competing perspectives of an issue, a resolution can be sought only by synthesizing diverse data and opinion, making judgments about arguments and evidence, evaluating information from inconsistent and imperfect data sources, and developing and arguing for a reasonable solution, or one that creates the best fit with the rest of our current knowledge of the issue, or one that redefines a problem in such a way that opposing perspectives are synthesized into a new framework. Accordingly, Kitchener (1983) argues that one who is faced with an ill-structured must necessarily ask if the problem is

solvable and if so, how it is solvable and whether there are strategies available to solve. She characterises such questions as epistemic in nature, and thus defines epistemic cognition as the processes involved to monitor the epistemic nature of problems and the truth value of alternative solutions.

Epistemic cognition, according to Kitchener, leads one to interpret the nature of a problem, inquire whether the problem is solvable under any conditions, define the limits of any strategy to solving it, consider in what ways solutions can be true, and whether reasoning correctly about the problem necessarily leads to an absolutely correct solution. Kitchener, however, contends that epistemic cognition is contingent upon underlying epistemic assumptions espoused by each individual and that these differences in epistemic assumptions become particularly critical when numerous individuals converge to resolve ill-structured problems. If complex ill-structured real world problems are to be resolved in a holistic, meaningful, ethical, and effective manner, then it becomes necessary that individuals involved have developed a level of epistemic cognitive maturity, to prompt the individuals to realize that multiple potentially valid perspectives on a problem exist which must be rightfully considered in order to develop a strategic solution.

Kitchener's work and that of other developmental psychology researchers (cited in Kitchener, 1983) indicates that epistemic assumptions evolve developmentally over childhood, adolescence and adulthood, and that changes in epistemic assumptions directly influence changes in epistemic cognition. Furthermore, this research strongly suggests that at least two kinds of developmental shifts occur particularly in late adolescent or early adult years, one which allows knowledge to be understood as contextual and the other which allows knowledge to be understood as constructed through integration and synthesis. Both these shifts, Kitchener (1983) has argued, are vital for the epistemic competence necessary to resolve complex ill-structured problems. For Salner (1986), who drew significantly on Kitchener (1983), these same shifts represents what she characterized as 'contextualizing sensibility' and 'flexibility in epistemic strategies' respectively, and are taken together as being essential for developing systemic competencies.

Pedagogic activities and interactions to foster systemic thinking in chemical engineering risk management: Having thus explicated why development of contextualizing sensibility and epistemic competence is vital for development of

systemic competencies, we can now identify practical pedagogic activities most likely to foster them. These have been synthesised from higher education pedagogic literature founded upon developmental intentions, and professional competence development literature pertaining to development in educational and institutional settings. Activities are enlisted below as guidelines toward productive ways of pedagogic engagement in chemical engineering risk management:

- **Engagement with ill-structured risk and safety oriented problems.** This follows directly from Kitchener's (1983) insight that exposure to ill-structured problems is vital to epistemic competence development. In light of this emphasis, problem based learning (PBL) emerges as a preeminent learning methodology, particularly because in it learning starts with and occurs through engagement with complex, authentic, ill-structured problems. There is now overwhelming evidence supporting its effectiveness in developing complex problem-solving skills and professional competencies (Illeris, 2009a; Litzinger, et al., 2011; Prince & Felder, 2006; Savin-Baden, 2003). It is widely adopted in engineering education because it models the ways engineers in practice (K. A. Smith, et al., 2005). However, what makes it particularly suitable to development oriented education, as Margetson (1991) has argued, is that it: (1) encourages open-minded, reflective, critical and active learning; (2) is morally defensible in that it pays due respect to both students and teachers as persons of knowledge, understanding, feelings and interests who come together in a shared educational process; and (3) reflects the nature of knowledge, as complex, dynamic and malleable, constantly shaping and shaped through the interaction of individuals with the larger classroom collective.

- **Creation of multiple opportunities for students to examine different points of view on a topic.** Ill-structured problems are characteristically multidimensional. Their resolution, as Kitchener (1983) has observed, relies on reframing multiple perspectives into a newer holistic framework wherein opposing perspectives are integrated. Provision of multiple opportunities for students to examine different points of view helps illustrate the ill-structured nature of problems. Furthermore, according to Salner (1986), it allows students to confront multiple explanations and conflicting perspectives, a useful and necessary step in their epistemic development toward multiplicity, wherein students begin to recognize and accept that an ill-structured problem can be validly examined and

understood from more than one perspective. Group discussions, debates, and presentations are perfectly conducive to highlight multiple perspectives of ill-structured problems and patterns of preferences for particular perspectives over others, which in turn can generate further classroom discourse that is essential for transformative learning (Brookfield & Preskill, 1999; Mezirow & Associates, 2000). Beyond their immediate appeal as pedagogic strategies for transformative learning, these also help foster a sense of community through group work, allow students to learn how to interact with different people and learn to rely on their advice and knowledge, evaluate reasoning and to make visible to the students the ontological, epistemological and methodological dilemmas involved in resolution of authentic ill-structured problems (Cullen & Harris, 2009; Jonassen, et al., 2006; Saltmarsh & Saltmarsh, 2008).

- **Creation of opportunities and provide encouragement for students to make judgments and to explain what they believe.** Judgment and decision making are critical to the appropriate resolution of ill-structured problems, and the practice of these skills is essential to competency development (Beckett, 2009; Dall'alba & Barnacle, 2007; Dall'Alba & Sandberg, 1996; Illeris, 2009a; Sandberg, 2000). More importantly, however, opportunities are necessary for students to judge and decide because these activities help develop epistemic cognition and move students toward a developmental stage of contextual relativism, wherein they realize that resolution of ill-structured problems is contextually constructed based on sound evaluation of alternative solutions (Bawden, 2010; Kitchener, 1983; L. Kuhn, Woog, & Salner, 2011; Salner, 1986). When epistemological development is emphasized, there is a need for students to practice making and defending claims in social contexts where claims must be examined and debated in a framework of alternatives and evidence (D. Kuhn & Weinstock, 2002). Case-based teaching emerges as a good fit for pedagogy, because students have opportunities to analyse case studies of historical or hypothetical situations that involve decision-making and problem-solving (Prince & Felder, 2006). Professional practice involves responding to ethical and moral considerations, prioritizing, balancing and accepting trade-offs of various kinds. Authentic, relevant, and suitably challenging cases provide students with the opportunities to confront the difficulties that real or hypothetical situations may pose, and allows students to explore potential responses, patterns of thoughts, and premises and beliefs underpinning their understanding of such situations. Prince

and Felder (2006) insist that provided cases are thoughtfully chosen, case-based teaching can help foster awareness, appreciation and understanding of professional and ethical responsibilities, knowledge of contemporary issues, and the ability to situate engineering solutions within larger contexts.

- **Creation of multiple opportunities for students to critically reflect upon personal and collective epistemic assumptions.** Critical reflection is a vital component of transformative learning as well as the development of professional competence (Boud & Falchikov, 2006; King & Kitchener, 1994; Mezirow & Associates, 2000; Schön, 1987). King and Kitchener (1994) highly recommend the use of reflective journals, response papers and other assignments and exercises where students have to deliberately wrestle with their own epistemic assumptions, personal preferences and justifications for their preferences, and emotional responses that impinge upon making a fully reasoned judgment. Salner (1986) suggests the use of open-ended written assignments that invoke critical thinking skills as a necessary means to urge students to generate their own syntheses and arguments in support of value positions, and more importantly to reflect on their own cognitive patterns and why they think the way they do. By engaging in these activities in a social setting, Bawden (2010) observes that students are necessarily engaging in examination of similarities and differences in the beliefs and values they hold as individuals regarding a particular issue, and begin to recognize that it is these differences in worldviews that are so often the cause of tensions between people as they seek consensus on understanding and judgments about normative actions.

- Creation of opportunities that make the content conceptually transparent to the students such that the links and relationships between various concepts and ideas which are fundamental to the topic of study become clear. Thinking systemically involves the exploration of relationships and interconnections. To this end, the use of concept maps emerges as an appropriate means to practice the ability to think systemically. A concept map, commonly described as a graph consisting of nodes representing concepts and labelled lines denoting the relation between a pair of nodes, is an excellent tool to represent knowledge and to articulate relationships in a manner that provides a big picture view of a topic (Hay, Kinchin, & Lygo-Baker, 2008). Gouveia and Valaderes (2004) maintain that concept mapping exposes the conceptions and assertions hidden within the

cognitive structure of each student, and offers the possibility to correct misconceptions and improve the learning process when used with sound feedback. Furthermore, as Ruiz-Primo and Shavelson (1996) have argued, when employed as an assessment tool, frequent mapping of particular concepts is likely to exhibit changes occurring in students' cognitive frameworks and aid in meaningful learning.

Resolution of ill-structured problems, group discussions, debates, presentations, case based teaching, reflective journals, and concept mapping are the main learning activities that emerge as most suitable for developing both epistemic competency and the ability to think systemically within a problem based learning environment. These methods provide ample opportunities for students to:

- Converse, discuss, express, exchange, examine and evaluate personal and collective views, values and interests relating to theoretical and practical aspects of risk and safety management;
- Mobilize their thinking abilities during such engagements as above;
- Tap into and connect prior knowledge and life experiences such as vacation work and so on;
- Exercise their engineering sensibilities, and powers of judgement and reflection;
- Actively make connections, contextual, and draw into relationships chemical and process engineering theory and practice with hypothetical and real-world risk scenarios and situations.

4.4 Conclusion

The question pursued in this chapter focuses on identifying and justifying pedagogic and assessment strategies that are appropriate for developing systems thinking as a core professional engineering competency. This has required an exploration of what it means to teach and learn a competency, in addition to understanding the process of development involved in learning to be competent.

It has been argued that teaching and learning must be understood as simultaneously shaping and being shaped by the ever changing context in which they occur. To teach is to engage intentionally in those activities which bring about learning. However, learning does not take place as a result of teaching but rather through a complex interplay of experiences, relationships and ideas being worked and reworked through the process of

reflection. Teaching and learning are conceptualized as interdependent processes which are at once complex, emergent as well as transformative, constructive as well as developmental, personal as well as social, cognitive as well as embodied. Knowing, in this sense, is a contingent, partial, ongoing process of meaning making and interpretive understanding, wherein perception is the creation of meaning by ordering those perceptions in a manner consistent with previous and/or current personal, cultural, and historical knowledge. Thus, learning is understood as an active search for coherence and consistency in understanding so as to guide future actions.

Given the above view of learning, learning to be competent at something is seen as an advanced kind of learning. It has been argued that a competency must be developed in and by the person, and is not simply a commodity to be acquired. Furthermore, it is argued that a competency is best developed only through practice. Actively putting a competency into practice fosters a better understanding of it while also promoting its development. This suggests that design for intentionality takes priority in pedagogic decision making. It has been argued that the most immediate implication for pedagogy is that the teacher moves from the traditional role of expert and transmitter of knowledge to facilitator, co-learner and co-constructor of meaning, enabling learners to connect new knowledge to existing knowledge. It is the responsibility of educators to support student learning and create effective learning environments and opportunities such that they assist students toward becoming competent professionals. Furthermore, it is proposed that formalized education ought to foster competency development through active learning that is problem- and practice- oriented and involves relevant judgment and decision-making as well as individual and social reflection.

In the previous chapter (Chapter 3) it was proposed that to think systemically implies conducting holistic inquiries to examine natural or social risk situations through the lens of wholeness, interrelatedness, connectivity, and emergence; a process of making an inquiry into natural or social risk phenomena by asking questions about existing or emergent issues and their interacting relationships. To mount such a systemic inquiry two commitments were chosen to direct our inquiry along certain lines of thought. These commitments are: (1) exercising critical self-reflexivity, social and ethical awareness when examining a risk management situation, and (2) recognizing, appreciating, and including multiple perspective or view-points. By committing to inquiring along these lines, it is proposed that one can meaningfully understand a

particular risk situation (event, occurrence, or phenomenon) and build a holistic picture of it.

Bearing in mind the above conceptualization of what it means to think systemically, the arguments presented toward the end of this chapter suggest that when it comes to the development of the above systemic commitments, the emphasis is first and foremost on epistemic development. Therefore, pedagogic and assessment strategies that privilege epistemic development become central to development of systemic commitments. Accordingly, it has been proposed that resolution of ill-structured problems, group discussions, debates, presentations, case based teaching, reflective journals, and concept mapping are the main learning and assessment activities that emerge as most suitable for developing both epistemic competency and the ability to think systemically within a problem based learning environment.

5 Evidence of Students Practicing Systems Thinking in PRM: Exercising the Commitments to Thinking Systemically

In the preceding chapter I addressed my inquiry's second guiding question: How can systems thinking be implemented in the study of PRM situations? I examined the literature on the theories and practices of educational competence development to deduce the kind of commitments and responsibilities I would need to exercise given that I have construed systemic thinking primarily as a form of competence.

I reasoned that students are more likely to engage and develop their ability to think systemically when they actively practice it. But I also argued that if the students are to truly learn and understand systemic thinking then there must be an emphasis on activity-oriented learning involving judgments, decision-making, and individual and social reflection. I explained that this emphasis is particularly vital to the engagement and development of systemic thinking because such activities are likely to invoke epistemic development, which is critical to the development of systemic sensibilities.

Thereupon, I identified that a range of activities are currently available which provide a suitable context for epistemic development as well as the practice of systemic thinking. These include activities such as the resolution of ill-structured problems, group discussions, debates, presentations, case based teaching, reflective journals, and concept mapping.

In this chapter I address my inquiry's third guiding question: How can an educator ascertain that students are engaging in systems thinking in the study of PRM situations?

First I describe a set of workshop activities I designed specifically to provide students opportunities to think systemically about PRM situations. The workshop sessions draw on the practical framework proposed in the previous chapter. The sessions provide the context for students to participate in assessment activities that specifically combine resolution of ill-structured PRM situations, case based teaching, discussions and reflective blogging

Next I undertake an evaluative stance and present evidence in the form of student responses to two such session activities. I identify the methods by which this corpus of evidence was gathered and highlight decisions pertaining to its analysis and

presentation. This section complements the methodological descriptions found in Chapter 2

Subsequently, the student responses that constitute the corpus of evidence are presented as narratives to demonstrate how students responded to selected sessional workshop activities *in situ*. Responses are exhibited to indicate how students were (1) recognising, appreciating, and including multiple perspectives or viewpoints (which may be contradictory) so as to evaluate their and own others' underpinning beliefs and values, and (2) exercising critical self-reflexivity, social and ethical awareness when examining a PRM situation.

Lastly, I argue that the assembled corpus of evidence suggests that students who participated in these workshop sessions were thinking systemically because their responses are consistent with those anticipated when the situative and constructive aspects of competence development are active.

5.1 Systemic Thinking Sessions: Description and Rationale for Workshop Activities

A set of workshop activities were designed to get students to think systemically about the interrelated topics of risk and safety, societal and ethical issues of risk and safety, and safety culture. In this section my emphasis is on documenting the motivations, decisions and actions taken in order to implement the workshops over a 12-week teaching period. I offer a first person perspective on the essential aspects of the process of workshop facilitation.

Over a course of 12 weeks, three workshop activities were executed. Systemic Thinking Sessions, as these workshop activities were called, were conducted in weeks 3, 6, and 9. The student cohort was large, with nearly 120 students. The students were divided into two batches. This reduced the participant pool for each session by half, and each batch of students attended either on the Monday or Tuesday of that particular week. The students decided, as per their convenience, which day they wanted to attend; and attendance was optional.

It was important to have the students exercise this choice so that their attendance, and more importantly, participation in these sessions was not only voluntary but a reflection of their own willing commitment toward competence development. As we shall see

shortly, the issue of making choices and exercising options is a key feature of the workshop activities. Coercion has no place in competence development, and this is particularly so when it comes to systemic practice (Flood, 1999; Jackson, 2000; Midgley, 2000).

Each workshop session addressed a particular thematic issue relevant to process risk management, but the three issues were interrelated. In week 3 the focus was on risk and safety as a societal issue. In week 6 the attention was on risk and safety as an ethical issue, and in week 9 we tackled the notion of safety culture. In exploring and treating the interrelated issues this way, I hoped that my students would come to understand and appreciate risk and safety from multiple perspectives. It was, as I saw it, an opportunity for the students to think systemically about risk and safety. After all, as has been argued in Chapter 3, one of the commitments to systemic thinking is recognising, appreciating, and incorporating multiple perspectives of any situation or issue so as to develop a more rounded or holistic understanding of it.

The workshop sessions afforded its student participants, individually and collectively, to share views, and uncover assumptions, beliefs, values, attitudes and feelings about and toward risk and safety. The workshop sessions were pedagogic opportunities for students to exchange and examine individual and collective worldviews, and possibly effect a personal worldview transformation through dialogue.

Discussion: Privileging the Process of Dialogue

The sessions briefly outlined above were a means to implement an activity-oriented approach to the development of systemic thinking. Each session privileged two specific yet interdependent epistemic processes so that students could exercise the requisite commitments. Discussion is the first of the two processes. In this section, I elaborate on how sessional discussions were conducted.

Discussion was a chief means by which it was possible to inquire systemically about risk and safety, and to explore the relationships and interconnections between risk related events, behaviours and actions of individuals and collectives such as communities, industrial organisations, and society.

It was my responsibility to facilitate the session and activities, initiate and guide dialogue, and to actively promote engagement and participation in the session activities, and I was greatly aided in the facilitation process with valuable suggestions found in

educational literature (Brookfield & Preskill, 1999; Mezirow & Associates, 2000; Savin-Baden, 2003).

The sessions were informal in tone, and at the beginning of each one I would first introduce the pertinent issue we were to attend. Thereupon I would invite the students to participate and engage with the ensuing activity. As a part of this invitation, I would remind students that the informality and open-ended nature of discussion meant that they were free to participate and engage in a manner they deemed appropriate and valuable to them, and that there was no pressure of compulsory contribution or participation in the session, nor would anyone be penalised or adversely affected from an assessment perspective for an apparent lack of engagement and participation.

I felt strongly that this was an important and necessary step to take to promote competence development, and learning in general, given the significance of a convivial learning atmosphere for productive engagement and meaningful participation in classroom activities (Boshier & Huang, 2008; Claxton, 2009; Fitzmaurice, 2010).

All three sessions had the same underlying purpose, to enable students to exercise the commitments that constitute systemic thinking. Firstly, dialogue and discussion provided an opportunity to think holistically about the issue in question. This was accomplished when the session participants shared their views about the issue and in the process of doing so realised that an issue can be explored from multiple perspectives. Given that there were multiple perspectives, I would guide the discussion further to highlight the emergent patterns of preferences toward some perspectives over others, and invite participants to become critical of those choices by mining the assumptions underpinning those perspectives and to reflect on them both during the discussion and thereafter.

In this way, the workshop participants would exercise the ability to become critically reflexive. Furthermore, since the issues considered risk and safety in terms of social, ethical and cultural dimensions, I anticipated that participants would develop their social and ethical awareness of risk situations, understand how risk roles interact, what consequences result from such interactions, and how the relations and interactions may be better managed. In this way both systemic thinking commitments were practiced through engagement in sessional activities.

The sessions also shared a similarly straightforward format. Ideally 1-1.5 hours was perfectly sufficient to sustain genuine interest and engagement in the session through

the use of either a risk case study or scenario. Case relevant information was presented in classroom handouts to all the participants who were then asked to work in impromptu groups.

The size of the group was not a major determinant, although I did stress greatly on diversity as this was likely to generate multiple perspectives during discussions. My preference was for quality in the group interactions, and group size became a vital play variable. There is a tendency for students to form groups with people who are familiar or likeminded. Often familiarity and like-mindedness make for petty discussions and detract from a genuine encounter with competing or conflicting worldviews. As a remedy for such an occurrence, in each session I invited the participants to forge a new group, or borrow, lend, or swap members to form smaller or bigger groups than their previous ones. However, useful as this remedy is, I did not see it as mandatory. Familiarity and like-mindedness helped highlight patterns of preferences *within* groups, and the contrast *across* groups; and both occurrences served to steer the discussion into the realm of assumptions, beliefs, and values that underpinned those preferences.

The session handouts contained the instructions for a group-think activity pertinent to the issue to be addressed. The groups would have to think about the case or scenario presented to them based on a set of guiding questions in the handout. 15-20 minutes were allotted for intragroup discussion, and we would subsequently launch an intergroup dialogue to exchange views and reasoning. Over the course of three sessions it became apparent that shorter duration intragroup discussions were effective in combatting idle chatter. Short intragroup discussions provided more time for intergroup dialogue, resulting in more productive interactions and insights.

In week 3 when risk and safety were explored as societal issues, the classic Ford Pinto case was considered (See Appendix 1). This case study was extracted from an educational resource on safe design created by the Australian Safety and Compensation Council (ASCC, 2006). The subsequent intergroup dialogue aimed at working through participants' perceptions, assumptions, and values in relation to that case.

With that in mind, I guided the discussion to explore a variety of conceptual questions: What does it mean to feel safe? In what ways does society secure safety of individuals and collectives? Is there a difference between feeling safe, and being safe? How does a community, organisation, or business ensure its safety and that of others? Can a sense

of safety be communicated, and if so, how would we proceed? And, how does the practice of risk management foster a sense of safety?

In week 6 the ethics of risk and safety were the foci of group activity and dialogue. A scenario was chosen to highlight an ethical dilemma confronting a fictional engineering professional, Sally Proctor, the European Regional Engineering Director for Kudochem, a multinational chemical manufacturing company with several processing facilities in the UK, Germany and the Czech Republic (See Appendix 2).

This scenario was adapted from the educational resource on engineering ethics in practice created by the Royal Academy of Engineering (RAE, 2011). It seemed particularly appropriate to foreground the connection between personal and public safety and respect for life, law and public good, and highlights how safety has emerged as a valued ethical imperative for all chemical engineers.

The activity required the participants to make a choice between three suggested approaches to resolving Proctor's dilemma and to justify how their particular decision was ethical defensible. The intergroup dialogue that followed the intragroup discussion aimed at debating those decisions in terms of risks and consequences, and discussing how documents such as the statement of ethical principles (SEP) by the Royal Academy of Engineering (RAE, 2007) may be useful in the decision-making process.

In week 9, the final session, the notion of safety culture and its relation and significance to risk management was explored. The issue of ethics addressed in the previous session provided a natural segue because being an ethically aware chemical engineer is integrally linked to the notion of safety culture (IChemE, 2007, 2012). The activity required the participants to organise themselves into larger groups (10-12 members). Incorporating diversity in terms of personal and cultural backgrounds, age, and professional experience was an essential prerequisite in this instance as this would likely result in the exchange of alternative personal and collective worldviews.

A mix of international students from various countries with domestic ones, as well as those of mature age with diverse professional experience alongside undergraduates with vacation work or internship experiences was particularly beneficial and efficacious for generating a diversity of perspectives. Each of these large groups was to role-play as a board of members of a chemical engineering company, specialising in a particular industrial process or operation of their choice, and each board member needed to

choose a suitable position such as an executive and employees of that company or allied industry professional or specialist consultant (See Appendix 3).

Subsequently, each company board group was to conduct a meeting to plan for a presentation to their respective board of investors and stakeholders on their company's safety culture. The purpose of the meeting was to consider how each company interpreted the open-ended notion of safety culture, what might constitute the essential elements or attributes of such a culture and the corresponding practices that those elements will consequently entail.

The emphasis in the above role-play activity was on the simulation of the meeting and its projected outcome, not on the actual presentation. The presentation was simply a hypothetical event to help contextualise the board meetings. 25-30 minutes were allotted for this meeting, and once the board groups had developed their ideas, an inter-board discussion was launched to exchange views on how safety culture is interpreted and subsequently translated into a set of possible corporate safety assurance practices.

I took on the responsibility to guide the inter-board discussion so that we could jointly explore what aspects of those elements and practices rendered them as being 'cultural', whether certain cultural elements and practices are complementary or antagonistic to one another and if and how those practices may be abused or misused. We examined notions such as assurance, compliance, liability, standards and codes, values, behaviours and attitudes, incentives and penalties, blame and responsibility, reporting and whistleblowing, and unfair practice and misconduct as issues of general culture as well as safety culture.

The point of the entire exercise, that is the initial group discussion and the subsequent class discussion, was to have the participants experience the dialogic character of the interaction integral to the development of systemic understanding. The participants were required to think systemically about the notion of safety culture.

My hope as the session facilitator was that participants would become receptive to not just the issues discussed but also the process by which those issues were explored. To increase the likelihood that the participants become attuned to the underlying process, I mentioned to the participants that the accompanying reflective blog exercise (See details in Section 5.2.2) was entirely based on this classroom activity and that their

attentive engagement was critical if they were to respond to the reflective blog accurately.

Reflective Blog: Privileging the Process of Reflection

Reflection is the second process. Competence development is incomplete without appropriate opportunities for personal reflection (Dall'Alba & Sandberg, 1996; Illeris, 2009a, 2011c). The sessional discussions allowed the students to experience and engage the approach to thinking systemically about risk and safety from multiple perspectives. I had hoped that when the approach is modelled in this way, the students become receptive to not just the issues discussed but also the process by which those issues were explored.

However, to ensure the likelihood that the students indeed become attuned to the process of engagement, it was imperative that they attempt to put the process into practice independently without my guidance, and in doing so invoke their meta- and epistemic cognitive faculties. This is best done through some form of contextually appropriate reflective practice. With that in mind, I included a post session reflective exercise that required the session participants to reflect on their own experience of the session activity and the issues addressed through a personal reflective blog. Below, I describe how reflective blogs were designed.

The themes and issues of each session (as described in Section 5.1) were retained for the reflective blogs as well. This was a deliberate strategy to improve the likelihood that my students were receptive to the issues discussed in the sessions. Accordingly, the overall aim of each reflective blog exercise was to provide the participants an opportunity to further contemplate the themes and issues addressed in the sessions.

For example, **in week 3** the subject of reflection was public risk perception of technology and industrial processes. The students were provided two articles, one discussing public attitudes towards nanotechnologies (Pidgeon, Harthorn, & Satterfield, 2009), and another investigating the case of nuclear energy and public acceptance (Grimston, 2007).

They were required to choose one of them and discuss what they perceived to be the most important issues to emerge in the chosen article, and how it related to the Ford Pinto case study from the workshop session as well as process risk management in general. In addition, the students were invited to reflect on any one incident from their

lives when their own perception or that of someone they know had impeded acceptance and subsequent use of any particular technology, and how they managed to overcome their reservations (See Appendix 4).

The article provided **in week 6** was itself a reflective account by a chemical engineer and director of safe operations of an explosives manufacturing plant (Harris, 2004). In it the author discussed the ethical dilemmas that emerge in the practice of safety assurance when industrial accidents occur, resulting in fatalities and penal action. Participants had the opportunity to further contemplate the matter of safety related ethics and responsibilities; each student had to consider and discuss the ethical considerations implicated in Harris's descriptive account, and reflect on why ethical conduct necessarily extends across and includes everyday personal, social and professional life (See Appendix 4).

On two previous two occasions, participants had journal articles to guide their contemplation on related issues. For the final reflective blog, **week 9**, no articles were provided to guide contemplation. This was a very deliberate pedagogic move to promote independent thought. Safety culture was the concept in question, and the students were required to conceptualise it holistically while also highlighting how thinking about safety culture in their own way has provided them individually with a particular point of view.

The classroom discussion was formative in that it would likely yield several noteworthy viewpoints and ideas which participants could contemplate over in their reflective blog responses. Although no articles were made available, their use was welcomed. Searching for and using them appropriately, however, was left to the students' discretion so long as credible sources were referenced and cited correctly (See Appendix 4).

All the reflective blogs followed the same basic format: first-person accounts with a maximum limit of 1000 words, where an informal style was welcome although no derogatory language was acceptable. Personalisation was vital, participants were invited to develop their own thinking and express it in their own words.

Students had a fortnight to submit their responses, which upon submission were available for review and feedback by the facilitator and respective group members. It must be noted here that these group members were those that constituted the regular

weekly classroom activities not the ones from sessional impromptu groups. The group members had the opportunity to comment on one another's responses, and to seek clarifications and/or offer alternative perspectives.

In my role as facilitator, having had access to the responses of all groups and members, I provided students feedback on the patterns and trends in the responses and guidance on how the responses can be improved. My emphasis in such feedback was to highlight how issues were being thought about and what aspects were being neglected and could be incorporated.

In designing and executing the reflective blog exercises as described above, I hoped that both the situative and constructive aspects of the learning process would become apparent to the students. As a result of engaging in the blogging activity they would come to appreciate that different participants are likely to consider different issues based on their own personal perceptions and worldviews, and further, that those differences in personal perceptions and worldviews are likely to prompt various participants to develop unique interpretive blog responses that are personally meaningful.

5.2 Decisions Concerning Evidence Gathering, Interpretation and Presentation

As stated in the chapter introduction, my intention is to demonstrate how sessional activities and processes described earlier provided students the opportunity to develop their ability to think systemically about multiple risk and safety related issues. In the forthcoming subsections, exemplars of student responses are presented to demonstrate systemic thinking in action. These responses indicate that the students were exercising the two commitments that constitute the ability to think systemically about ill-structured process risk management related situations.

Responses have been organised in terms of the individual commitments. The first of the two commitments – exercising critical self-reflexivity, social and ethical awareness when examining the ill-structured situation – is showcased in the first collection of cases in Section 5.3 below. The second commitment – recognising, appreciating, and including multiple perspectives or view-points that constitute the ill-structured situation – is showcased in the second collection of cases in Section 5.4 below.

It is important to note, however, that these two commitments are interrelated and enfold into one another, thus making it impossible to separate them in reality. They are embedded into the ill-structured nature of the activity, and in and through the activity the commitments are enacted simultaneously. The distinction between the two commitments is merely made for the purpose of demonstration.

I recorded all the sessional discussions using a digital audio recorder. In addition, I had access to all online reflective blog responses as well. They were downloaded and stored upon submission at the allocated deadline (See a selected sample of these responses in Appendix 5 – Appendix 10). The digital audio recordings and the reflective blog responses are the chief sources from which pertinent data was gathered, and subsequently interpreted.

On studying both the above sets of evidence, a few things became clear. The discussions had provided participants the opportunity to exchange various perspectives. However, the interactive and fleeting nature of the verbal exchanges between several participants, often speaking simultaneously, limited the possibility to deeply explore numerous issues that emerged during the discussions. Issues were raised or highlighted, but their examination was done cursorily.

Dialogue shifted from one topic or issue to another over the course of each discussion in a short span of time. This naturally makes it difficult for anybody to remain attuned to all that is said about any particular issue. It is even more challenging to remain attentive throughout the entire session. Yet, despite the above limitations, the discussions complemented the process of reflection in that they gave participants one or more key issues and noteworthy viewpoints to contemplate. The process of reflection gave them far more time to dwell on, understand and examine various aspects of the issues than that afforded by fleeting exchanges of the discussions.

The discussions proved to be formative to the reflective blog exercise. They influenced what and how various participants reflected. Owing to these factors, I decided to privilege reflective blog responses over discussion excerpts for demonstration purposes. Consequently, in order to demonstrate that students had exercised the first commitment, I have chosen to focus specifically on the reflective blog responses in Week 6. However, for the purpose of demonstrating that students had exercised the second commitment, it was necessary to use specific reflective blog responses as well as transcribed snippets of the session discussions in Week 9.

It is important to state my reasons for choosing responses from Week 6 and 9. The session themes, although interrelated, were selected so that the participants became increasingly conscious that process risk and safety management is a socio-technical process that crucially requires socio-cultural and human factors to be carefully considered in addition to such issues as legislative compliance, duty of care, and financial viability. It was necessary that as a result of the session activities the participants came away with the realisation that while safety is certainly paramount in design and operation of industrial processes, it must always be approached proactively rather than reactively.

In order to bring out this realisation, it was imperative that the participants were introduced to the notion that risk and safety are subjective and perspectival. Beliefs, experiences, feelings and attitudes, together condition not only perception of risk and safety, they also influence all risk and safety related conduct. It was necessary to provide the opportunity to participants to realise human complicity in risk and safety situations. Accordingly the sessional themes were chosen to make this increasingly obvious to the participants.

In Week 3 the emphasis was on acquainting participants to the notion that perceptions of risk and safety are governed by beliefs, experiences, feelings and attitudes. In Week 6 the emphasis was on demonstrating that differences in perceptions, beliefs, feelings and attitudes, lead to differences in risk and safety related actions. Finally, in Week 9 the emphasis was on demonstrating that maintaining, improving, or changing safety culture requires the ability to effectively manage the differences in risk and safety related perceptions, beliefs, feelings and attitudes, and conduct. In this way, the succeeding theme reinforced the preceding one. It was anticipated that the participants would develop an increasing understand that issues of risk, safety and safety culture are complex and ill-structured in nature and demand the ability to think systemically about them.

According to the above scheme, the activities in Week 6 and Week 9 provided the participants the most obvious opportunity to realise how human complicity can influence risk situations. It also provided them the most obvious opportunity to realise how systemic thinking can be productively exercised to examine human complicity in those situations in terms of relationships between risk-related events and human

conduct, and the consequences that result from human interaction. Owing to these reasons, I chose to focus on student responses from activities in Week 6 and Week 9.

These responses have been interpreted, organised and presented in a narrative form. The reasoning for this is as follows. Its use appeared prominently across the data that was gathered. Students responded narratively. They made sense, explained and reasoned, and communicated in descriptive fashion. The "narrative mode of thought" (Bruner, 1986) allowed them to analyse and reflect on the safety and risk related issues they encountered in the session activities.

Consequently, I have, in turn, presented student responses narratively so as to maintain their narrative integrity. In doing so, I have allowed the narratives excerpts to display and capture my students' experiences, time, personal knowledge, and process of reflection and deliberation (Clandinin & Connelly, 1991). This decision pays due regard to the increasing acceptance of the fact that the narrative approach is well suited to capture the complexities of competence development in general (Beckett, 2009; Dunne & Pendlebury, 2003; Gudmundsdottir, 2001; Pendlebury, 1995; Perrotta, 2009) and the development of holistic or systemic thought in particular (Mattingly, 1991; Schön, 1987; Tsoukas & Hatch, 2001).

The task of demonstrating the practice of systemic thinking in the activities of Week 6 and Week 9 has required a two-tiered interpretive format. At the first level, narrative excerpts are presented in order to highlight the various and personally meaningful ways in which individual session participants responded to accomplish the main task required of them in each activity. Section 5.3 below and Section 5.4 below operate at this level. Thereupon, at the next level, all the above responses are revisited briefly and reviewed together in order to demonstrate how in responding in such unique and personally meaningful ways the participants were thinking systemically in relation to the two tasks they were set. Section 5.5 below is indicative of this higher level interpretation.

5.3   Student Responses to the Practice of the Commitment of Exercising Critical Self-Reflexivity, Social and Cultural Awareness

The Systemic Thinking Session **in week 6** addressed the ethics of risk and safety and the post session reflective blog exercise retained that theme. It invited session participants to contemplate the ethics of safety and the responsibilities that come with it. To stimulate their interest in the matter an article was provided which offered a reflective

account of a professional chemical engineer and Director of safe operations of an explosives manufacturing plant (Harris, 2004).

The students had to discuss the ethical considerations they perceived to be implicated in that descriptive account, and reflect on why ethical conduct necessarily extends across and includes everyday personal, social and professional life.

The main objective of systemic thinking is to learn our way forward into the problematic situation and to construct the richest story about a situation that is perceived to be problematic by seeing the world through the eyes of another (Checkland, 1999; Churchman, 1968).

The ethical considerations implicated in Harris' (2004) account constituted a problematic, ill-structured problem. The reflective blog exercise invited the participants to explore that account holistically by being critically self-reflexive and mindful of the social and cultural dimensions implicated therein. Participants were required to develop a richer story of why the situation described in that account was inherently problematic from an ethical perspective.

This is precisely what the reflective blog exercise enabled the participants to do. Primarily, the responses were a way for the participants to make sense of, explain, and communicate their own perspectives and for other members of their respective groups to view the world through the eyes of these participants. In order to better appreciate the various participants' responses, however, the Harris account is recapitulated below.

Harris' Cautionary Tale: Summary of the Article

Brian Harris was the joint managing director for production operations and health and safety of personnel at Nobels Explosive Company Limited. During his tenure, on 14 June 1988 an explosion occurred at Cookes Works in North Wales, a site at which the company manufactured nitroglycerine based explosives in the form of gelignite.

Two employees, they were operators, died in the explosion. Harris subsequently established a detailed investigation into the incident to identify the likely cause of the explosion and the deaths. The investigation revealed that while a plant design or maintenance oriented deficiency was the most likely cause of the explosion, it was, however, not the reason for the deaths of the two operators.

They were killed because they were in the wrong place during the explosion, and their being there implied they were not following prescribed procedure. Furthermore, the investigation revealed that their actions were not one-off behaviours, they were serially cutting corners and other employees were very well aware of this fact.

The above investigation was conducted in coordination with the police and the Health and Safety Executive (known as HSE, and henceforth addressed by this acronym). The mission of the HSE is to prevent death, injury and ill-health in Britain's workplaces, and to promote the safest workplaces in the world to work while reducing the economic and social costs of health and safety failures. In relation to these aims, they seek to legally prosecute people who put others at risk especially when it is found that there was been a deliberate flouting of the law.

As a result of the investigation, the HSE determined that Harris was not negligent in his corporate responsibility toward the health and safety of Nobels' employees. But they did bring a case against the company and succeeded in prosecuting it for failing to ensure the safety of employees by lack of supervision of compliance with operating instructions for the safe mixing of explosives. The company subsequently pleaded guilty to the charge and was financially penalised.

Harris's account of this entire experience is aimed at developing lessons from it that can serve and remind directors, managers and engineers that they are directly accountable for the health and safety of their employees, subordinates and colleagues, and that failure to meet all the requirements all the time may result in severe corporate and personal penalties through ultimate judgment before the Courts.

The information presented above should be sufficient at this stage to introduce individual participant perspectives on the ethical issues emerging from the above description. Further details from the above account are introduced appropriately at various points within the context of each participant's response.

We can now comfortably proceed to appreciate various participant perspectives.

Participant Responses: Dell, Noam, Carrie, Ken, Freya and Chuck

This case centres on the responses of six participants – Dell, Noam, Carrie, Ken, Freya, and Chuck – to the reflective blog exercise involving the Harris account summarised above. These six participants belonged to different groups and had very different

personal, professional and educational backgrounds. Dell, Noam, and Ken were mature-aged students with diverse professional experience in the chemical and process engineering industry. Carrie, Freya, and Chuck were full-time undergraduate students enrolled in the chemical, biochemical, and mining and metallurgical engineering courses. All three had completed one or more stints of vacation work experiences with companies specialising in chemical and process engineering, mining, and oil and gas engineering.

Their responses were chosen because each articulated their points of view in unique and personally meaningful ways. They successfully conveyed one or more ethical issues that they perceived have emerged from their examination of the Harris account. It has been claimed that different people 'read' problematic, ill-structured situations differently (Checkland, 1999). These participants elaborated and ably communicated their 'reading' of the problematic aspects of the ill-structured situation described by Harris (2004).

In responding as they did to the task assigned in the reflective blog exercise they were invoking the complex learning processes that underpin competence development (described in Chapter 4). Each of them raised or focused on a different issue based on their personal worldviews. Consequently, each developed a unique interpretative narrative to explain and communicate their understanding.

By presenting as follows the six participant responses to the reflective blog activity from Week 6 it will be possible to demonstrate in Section 3.2.3 how these responses serve to suggest that the participants were activating their individual abilities to think systemically about the issues emerging from the Harris (2004) account.

Dell implicates managerial oversight

Dell developed his interpretation around Harris and his actions and argued that Harris "did indeed fulfil his ethical obligations to provide a safe working environment but perhaps failed to ensure they were properly carried out" because he was "too trusting" of factory management. Harris had stated in his account that the factory at Cookes Works employed about 100 people and it was a close-knit family.

Dell interpreted that the close-knit familial culture at the Cookes Works factory was ethically problematic, leading Harris to become too trusting and the factory management being negligent of their ethical responsibility to safeguard and maintain the health and wellbeing of factory employees. He argued that managerial oversight is

an important ethical issue. In justifying that claim he also manages to implicate not only Harris but also the factory management:

It is perhaps here that an ethical dilemma occurred. Although such a culture is good to foster effective working relationships between individuals, there is the risk that the culture goes too far and impinges on good sense. The fact that two employees were able to routinely breach procedure by being outside during a mixing cycle, points to a negligent attitude from the factory management. This could perhaps have occurred due to the close-knit working relationship allowing seemingly minor breaches of procedure to go unchallenged. The managing director in this case would have had an ethical responsibility to make sure the factory management did not let their interpersonal relationships interfere with proper procedure. Given the incident that occurred it surprises me that the factory management were not individually charged with criminal negligence or manslaughter due to their unwillingness to enforce proper procedure. The hierarchy of the organisation seemed to show that the managing director was responsible for producing effective working procedures and the factory management were responsible for enforcing them. In this light the author did indeed fulfil his ethical obligations to provide a safe working environment but perhaps failed to ensure they were properly carried out.

In the above passage, Dell's attention on the hierarchy at Cookes Works is directly developed from an organisational graphic Harris provided in his written account. The reference to the charge of manslaughter is not random either. Harris mentioned that the manslaughter charge was likely in light of the HSE's strong desire to prosecute individuals rather than companies if at all possible. Dell uses this point to implicate individuals that constitute factory management.

In clarifying his personal involvement at Cookes Works, Harris has stated:

I visited Cookes Works four times per year. I always walked round the factory and spoke with employees and would generally take a closer look at one particular part of the factory while it was in operation. I would invariably have informal meetings with operators and supervisors, and always met with safety representatives. I would review with the works manager progress on action plans, outcomes of audits and their close-outs.

High priority was given to critical safety-related expenditure. I felt I had a good relationship with the factory, the management and the employees. We had good, open, two-way communication. (Harris, 2004, p. 6)

Dell refers to Harris's visitations and audits and casts a further doubt on factory management in the following way:

Given that the author visited the site four times a year and there were area audits, it surprises me that he was not made aware of the common breach of procedure that was occurring. This also leads me to suspect the existence of an "old boys club" within the factory working environment, especially considering the breach of procedure was documented in the log books and so should have been readily apparent to an inspector.

It was, of course, perfectly reasonable for Dell to think this way. The investigation, according to Harris's own account, had revealed compelling evidence suggesting that the two operators who died were routinely falsifying the plant log book and that the other employees were well aware that the two were regularly breaching set procedures. If Harris was diligently addressing his own responsibilities then in all likelihood the factory management cannot be above suspicion. At the very least it raises the possibility of managerial oversight.

Noam canvasses the issue of differences in ethical understanding

Like Dell, Noam also developed his own interpretation around Harris and his actions. But interestingly he focuses on a very different issue. Two episodes from Harris's account attract his interest. One concerned an executive decision involved in dealing with nitroglycerine in the second mix house. The explosion had destroyed one mix house while the other withstood it but contained a charge of nitroglycerine waiting for its next batch. This remnant charge in the second mix house was liable to self-initiate unless it was removed within 10-14 days. This posed a significant risk and an executive decision was necessary to manage that risk. This task was an important aspect of the recovery plan for the factory which needed to be undertaken by 15-18 June 1988. Harris wrote:

Since we had not established the cause of the explosion we could not process the nitroglycerine sitting in the second mix house. The HSE believed the only way forward was to explode the building. That would have ended production at the factory and the loss of significant employment for the

area, so we eventually decided to hand carry the material back to the main

storage in rubber buckets. Two people willingly volunteered to carry out the

task. The task was carried out on Friday evening and was complete by

10:00pm. A major milestone for the recovery plan was achieved. (Harris,

2004, p. 7)

The other episode concerned a frank admission by Harris of feeling both relief and reservation on account of the HSE's decision to bring a case against the company rather than prosecute him personally for negligence. Harris reflects on the period of uncertainty in the wake of that explosion at Cookes Works:

Would I fall victim to the pressure to prosecute directors of companies? I

had a strong personal belief that I had not been negligent and that I had

carried out my role to the best of my ability. Eventually, I was notified that

the HSE would be bringing a case against the company rather than a

personal prosecution. This was a great relief to me but a concern that, in

spite of the arrangements and background I described earlier in this paper,

they believed they had a case against the company. On 29 March 19980 in

Mold Crown Court the company was prosecuted under section 2 the Health

and Safety at Work Act for failing to ensure the safety of employees by lack

of supervision of compliance with operating instructions for the safe mixing

of explosives. On legal advice the company pleaded guilty, which was

difficult for me and my colleague managing director to accept. (Harris,

2004, p. 9)

Noam viewed these episodes as ethical dilemmas and highlighted to his group members that it is important to acknowledge that we cannot in prevailing times assume that everyone understands what it means to be ethical in the same way, and consequently, what is understood as ethical behaviour is rendered problematic. He argued that possible differences in what constitute ethical behaviour and action is likely to emerge as an ethical issue.

To introduce his perspective Noam recounts an episode from his own life owing to which he arrived at the notion that ethics is both vague and uncertain and that these qualities are likely to frustrate ethical decision making. He wrote:

I was first introduced to ethics during post graduate studies in business. The semester long course introduced us to not just the various definitions of what ethics and ethical behaviour might be, but also to the various ethical theories which might be employed in order to analyse or support behaviours/decisions. These ethical theories ranged from 'Cognitivism and non-cognitivism, Religious morality, Consequentialism vs. non-consequentialism, Utilitarianism to Kantianism and Natural law'. All of which may be employed as a position from which to argue your stance, hence my comment referring to inconsistency and uncertainty.

Noam hinted to the idea that any action can be argued to be ethically defensible depending on the interpretive framework one uses to justify it. The fact that a variety of interpretive frameworks do indeed exist only goes to further strengthen that claim. Defending any action as ethical then may simply require that one identity which interpretive framework is amenable to that purpose.

Not content at simply hinting at the significance of this point, Noam goes on to illustrate his reasoning as follows:

As with all good engineering practice, let's start with a static definition: "Ethics is commonly defined as a set of principles prescribing a behaviour code that explains what is good and right or bad and wrong; it may even outline moral duty and obligations generally"(Henderson, 1992, p. 51). This seems simple enough, however because of the very dynamic environments in which we all live, this definition is clearly too vague to be useful and so it's back to where we started. This is because it presumes that everyone agrees and adheres to not just the same ethical principles, but also to the same level of ethics, which is not the case in today's pluralistic society. These diverse views found in our society are attributed to changes over time in our different environments (social, religious, corporate etc.), such as shifts in cultural values, creation of conflicting interest groups, demise of Puritan based ethics as well as the ever increasing tendency to use legal criteria as a basis for ethical decision making. This is clearly illustrated in the article by Brian Harris where he voices his discontent with the decision by the company to plead guilty and pay the fine. Brian and his colleague, as the MDs, were certain that they had been diligent and ethical in their (and by

extension their companies) behaviours, but the company for which they worked believed otherwise (for legal reasons).

In the above passage, Noam not only illustrated his reasoning but situated Harris's simultaneous feelings of relief and concern as well as his apparent difficulty in accepting the company's decision to plead guilty given how this would implicitly reflect back on Harris and his colleague managing director's managerial competence. Chiefly, though, Noam brought to his group's attention what is moot is that we cannot in prevailing times assume that everyone understands what it means to be ethical in the same way. To support this view, he refers to Harris's "frustration" that the company decided to plead guilty to the charges brought against them by the HSE, as shown below:

His frustration was born out of the fact that he believed that he had high ethical values with respect to the safety of his employees and this was illustrated in the way in which he personally prioritised safety and the degree to which he took a special interest in it. He assumed that everyone beneath him also prescribed to same level of honesty, integrity, responsibility, and respect for the rule of law, care for other people's wellbeing/safety and that they demanded the same level of accuracy and rigour in their assessments. As can be seen from the outcome of the enquiry, this is not the case. The employees that were killed by the explosion did not have the same ethical viewpoints or understanding as their management and so were willing to take risks by cutting corners (not following procedures) in order to satisfy their need for more time in the canteen. The management within the company did not pick up this behaviour (not rigorous enough) nor did they act upon it (respect for life/public good), again because of differing ethical viewpoint's/understanding.

As seen above, Noam not only exposed Harris's basic assumption about uniformity in ethical understanding but also argued that the assumption was not wholly shared by the operators and factory management as evidenced from their respective actions. In the Systemic Thinking Session that week, the statement of ethical principles (SEP) by the Royal Academy of Engineering (RAE, 2007) was handed out to participants for the workshop activity.

The document outlines accuracy and rigour, honesty and integrity, and respect for life, law and public good as three of the four principles of ethical engineering practice. Noam

has been both mindful and resourceful enough to invoke them in the above passage to point out the actions of the deceased operators and the factory management as failures from the perspective of those three ethical principles.

Subsequently, attempting to give further credence to the fact that differences in ethical viewpoints do in fact lead to very different actions, Noam has recruited the episode involving the recovery of nitroglycerine from the second mix house:

> *Another ethical dilemma occurred when the remaining batch of nitro-glycerine was removed by hand instead of the batch being destroyed through detonation, as was recommended by the HSE advisors. The HSE advisors wanted the option with the least risk to personnel, but the company did not want to endure further destruction and commercial loss. More lives were put at risk because of the decision. This is a good place to highlight the fact that because of the differing degrees of ethical behaviours that are found in both our personal, social and professional lives, we must always strive to create and promote adherence to a robust and adequate set of ethical guidelines/principles (as can be found in Statement of ethical principles by Royal Academy of Engineering) in our professional lives as well as in our personal lives (Puritan type ethics or similar ethical philosophies).*

From Noam's description it is clear that differences in ethical understanding are likely to lead various individuals to undertake different courses of actions and defend them as ethically defensible. Noam understood this and accordingly made a case for the importance of a document like the SEP by the Royal Academy of Engineering (RAE, 2007) as a sensible and legitimate device for making sense of ethical imperatives and developing a shared understanding on the most ethically defensible course of action. In making a final plea in the matter he has concluded:

> *By subscribing to an agreed set of ethical principles, we are assuring a degree of parity in the decision making influences of the aforementioned. This is of paramount importance because clearly every individual decision/ethical behaviour of one will affect many.*

Carrie reflects on 'cutting corners' and its impact on people and procedures

Carrie constructed her response in such a manner as to foreground the tensions between employee-employer relations and the ethical issues that are likely to arise from

that relationship. Harris's account led her to ponder as to whom blame should be attributed and at what point one must accept responsibility for other people's actions. She believed that these questions ultimately lead to the recognition of the delicate balance between autonomy in personal action and corporate responsibility and that error of judgment in understanding the fine line between the two may likely generate what is deemed to be an unethical action.

Harris has remarked emphatically that the two operators who died in the explosion were killed because they were in the wrong place. During the mixing operation they should have been inside the reinforced control room bunker. The investigation had revealed that these two operators were routinely filling the plant logbook in for batches yet to be started, were regularly in the canteen at times that were inconsistent with the batch cycle times, and were, at the time of the explosion, probably moving the hazardous product of the previous batch while the next batch was in process. These were clear and repeated breaches of procedure, as Harris has noted:

> *It was obvious that these men were cutting corners, i.e. deliberate intent. It was clear that this was not one-off behaviour. There was no financial or any other general incentive to cut corners; it appears their behaviour was driven solely by a desire to have more time at the canteen. (Harris, 2004, p. 8)*

Carrie chose to reflect on the behaviour of the two operators, particularly their tendency toward cutting-corners. She has drawn on her own experience of working at a nursing home to comprehend such a tendency and the ethical implication of acting on it. She wrote:

> *Personally I keep asking myself why didn't they seem to care as to what they owed their employers? It raises a question in my own life – how would I respond if I was in their situation? In my casual job at a nursing home, I admit to sometimes 'cutting corners'; however the critical difference is that I can recognize the difference between cutting corners to save time (e.g. making one big pot of tea rather than everyone getting an individual cup), and cutting corners which impose potential significant risks to both myself and other such as not correctly sterilising cutlery.*

Although Carrie has disclosed to her group that she too has succumbed to cutting corners, she is well aware of differences of kind in such an action. She clarifies the

difference by the use of two everyday examples. Cutting corners to save time is a means to achieve some degree of efficiency. Her example of preparing tea in a large pot and then serving a cup of it to each of the nursing home residents rather than making tea in individual cups is as simple as it is persuasive. In contrast, however, if in wanting to be efficient one were cutting corners by deliberately deviating from correctly sterilising cutlery, then the act is alarmingly grievous because it poses a significant health risk to the nursing home residents as well as care-givers. By virtue of that fact alone such an act would be unethical because in the care-giving industry where caring is the primary imperative, such an act is as careless as it is reckless.

But Carrie is aware of the difference and she believes that such awareness is integral to acting ethically. She recognises that it is a person's inability to discern the above difference that is likely to raise ethical concerns. Furthermore, to her, the fact that a person is unable to discern that one's actions may likely jeopardise one's own safety and that of others and then proceeds to cutting corners that impose risk on oneself and others points to a flaw in personal integrity. As Carrie has put it:

> *It makes me recognize that a critical part of ethics is personal integrity; while the company does have significant control as to the wider processes and procedures that must be followed, there is always a point where individual actions, such as 'cutting corners' threaten the integrity of those procedures.*

Although Carrie does not explicit mention or refer to it in the above comment, her attention is drawn to the relationship between people and procedures, two of the so called 3 P's mentioned in Harris's account that are likely to lead to accidents. The deceased operators were cutting corners and they were repeatedly breaching set procedures while cutting corners.

In the above excerpt, despite the brevity of the statements, Carrie has made sense of the organisational point at which a person's action of cutting corners 'threatens the integrity' of prescribed procedures. Carrie has situated the person within the organisation by recognising that while it is the organisation that develops procedures which are not only efficient but safe, it is only at the level of the person that such procedures can truly be put into effect and it is here that procedures break down. The procedures break down not because of some inherent weakness, but because of weakness in a person's ability to discern the strengths and benefits of following set

procedures and the risks and consequences of disregarding them, as well as the weakness of personal integrity exhibited in proceeding to break from procedure disregarding the attached risks and consequences.

In the eyes of the Court the deceased operators had been negligent in performing their duty, negligent "in not following operating instructions" (Harris, 2004, p. 9). For Carrie, the issue of negligence and its relationship to cutting corners also merits examination. As we see below, she revisits the nursing home example to highlight the above relationship:

> *Tying into the notion of cutting corners, it is important to note the difference between 'cutting corners' and being negligent; while I make tea by the bulk so I can sit down and talk to my favourite residents for an extra 5 minutes here or there; this is still part of my job; moreover I am present in my location. As such I can see the pertinent difference between valuing the canteen social scene; rather than being on location, with residents. As an employee at the nursing home, I personally aim for myself to make as many residents smile as I can in one shift, whilst fulfilling my job requirements. If I can manage this while ensuring the safety of myself, my co-workers and residents, then I have met my own expectations, and my obligation to the company.*

For Carrie the time saved by the corner cutting exercise of making tea by the bulk allows her to invest the same time in promoting and maintaining the convivial atmosphere of the nursing home by occasionally engaging in conversations with some of the nursing home residents. Maintaining such an atmosphere is also a vital aspect of her care-giving responsibilities. Moreover, as she has pointed out, she is still within the prescribed place. Her actions in such instances cannot be construed as being negligent. Carrie realised the same, however, was not true of the operators. They were regularly found present in the canteen at times inconsistent with the batch cycle times, and it was also speculated that they were moving a previous batch of hazardous nitroglycerine when the next batch was in process at the time of the explosion. Doing that and being where they were during the explosion, instead of being present in the reinforced control room bunker, they were clearly in breach of procedures and were, in effect, negligent of their prescribed duties and responsibilities.

Carrie has realised that properly understanding one's responsibilities and actions, and conducting them with personal integrity in light of their ethical consequences on oneself and others, is integral to working to one's best potential. It helps to demonstrate one's own integrity and defend against possible questions of negligence. More importantly, however, as she has put it, it 'maximises safety in the workplace' and, following on from Harris's conclusion, increases "the probability that people in your organisation will not be injured and will return home each day to their families" (Harris, 2004, p. 9).

Ken, Freya, and Chuck examine the relation between unethical actions and consequences

The reflective blog exercise using the Harris account had two objectives. One was to provide the participants an opportunity to discuss the ethical considerations they perceived as being relevant in that narrative. The responses by Dell, Noam and Carrie amply demonstrate their ability to identify some of those issues, and how they developed their own understanding based on the facts that were central to Harris's description.

The other objective was to promote among the participants a clear recognition of the systemicity of ethical and unethical actions. By that I mean how unethical actions, personal or collective, have effects and consequences that spread far wider that those who undertake those actions. While Dell, Noam and Carrie displayed an awareness of this in the way they presented their ideas to their respective group members, their acknowledgement was less explicit. Some other participants, however, were more explicit about realising the relation between actions and consequences.

Ken, for example, chose to focus solely on the accident and analysed it in relation to what are known as risk roles. Risks are taken, run or imposed (Hansson, 2007). In every risk situation there are those who are exposed to a risk, those who decide to take, run or impose it, and those who benefit or suffer from that risk. Being able to identify the risk players helps us to understand the risk situation systemically because here the assumption is that a risk is realised owing to the interactions between risk players, rather than there being a singular cause. Ken used the above notion to guide his analysis. In his analysis, Ken directed his attention first to the operators who are referred to below as 'mixer workers', then to the other staff who are referred to as 'work colleagues', and finally to company management represented by 'supervisors and managers'. Aspects of Ken's analysis are presented below in the same order.

Ken believed that if the operators were more perceptive of the consequences of the risk they were taking or imposing then they may have likely desisted from taking them, but he has his doubts, as we see below:

> *If the killed workers had a sense of the real risk they may not have taken the indicated short-cuts - if a mixer worker still carried on with consistent breaking of significant safety procedures with real awareness of the risks then he or she would certainly put themselves and their colleague and anyone else in or near the mixing house at serious risk directly and indirectly by displaying behaviour that is against safety procedures, their ethics could be classed as questionable.*

Bearing the above reasoning in mind, Ken attributed to the two operators all three risk roles in relation to the accident. In that instance, the two operators were directly the ones exposed to the risk, chose to expose themselves to it, and were likely to gain from that taking that risk.

Commenting on the other staff, Ken wrote:

> *It is indicated that work colleagues knew about the short-cuts; if this is the case, then one wonders what action was taken by them (if any) to correct the noncompliance with significant safety procedures. Again the ethics of doing nothing in this regard would be questionable.*

Accordingly, applying the notion of risk roles to the other staff at the time of the accident, Ken feels that at least some of them may have been directly exposed to the risk particularly if they were near the mixing house. Although it is not indicated in Harris's account how many of these staff were aware that the operators were routinely cutting corners, on the whole, whoever knew seemed to carry the responsibility to caution the operators against such behaviour. To Ken it was clear that those colleagues "had the potential to both 'casually' and 'officially' try to correct the noncompliant behaviour", and consequently such an opportunity implied that the colleagues were partly decisive in the role they played in how the risk was realised. Moreover, given that opportunity, had they chosen to purposely avoid raising caution with the operators, then it may have meant that they too gained something from doing so. Ken speculated that perhaps non-confrontation had advantages such as 'smoothing work and personal relationships' and possibly avoiding exposure to the possibility that 'other areas were

also taking short-cuts'. Hence, based on this last implication, Ken attributed to the other staff all three risk roles in relation to the occurrence of the accident.

The factory management was not above suspicion either, for as Ken has put it:

> *If this short-cut behaviour was regular, then the supervisors and managers should have been aware of this non-compliant behaviour and acted to correct it and also increased their supervision/ monitoring of work procedures.*

Following Harris's account of how the company suffered severe corporate and personal penalties, Ken has identified that the company management was decidedly exposed to the risks imposed by the operators and was equally decisive in the risk being realised given that they had been unable to detect the presence of corner-cutting behaviour in the plant despite the fact that they had in place seemingly appropriate policies, practices and procedures for promoting and maintaining a positive occupational safety and health and environmental awareness.

By way of his analysis, taking the actions and possible alternative actions of the operators, other staff, and factory management as examples, Ken was able to explain the direct and indirect consequences of actions which are deemed unethical. Consequently, to him the ethical imperative is clear, as he puts it in his conclusion:

> *As can be seen in examples such as the above, being ethical in matters or events that can have direct serious consequences on the lives, health and well-being of yourself or/& others is critical to not only helping to directly prevent serious adverse effects on you or others (or the environment) but also indirectly though "setting an example" or "encouraging positive ethical behaviour".*

Freya, a participant from another group, also shared Ken's recognition that the risk actions of some can affect others. Her attention is drawn to one of the eight lessons Harris outlines in the end of this narrative, and it forms the basis for the point she wanted to make. She wrote:

> *For me personally, the lesson described by Harris that seems the most relevant to this case study, and is something that I hadn't considered in the past is: "How do you know that what is supposed to happen does happen?*

Too many assurance processes check hardware and systems and fail to assure what people actually do. How do you know that the procedures throughout your organization are being followed?"

For Freya it is what people actually do or do not do that creates the possibility for risks to be realised. The fact that other workers at Cookes Works knew about the corner-cutting behaviour of the two operators and seemingly did nothing about it was worrying evidence of complacency in both doing as well as not doing what one ought to do. She wrote:

Other operators and workers knew about the "cutting-corners" behaviour of the two operators, yet they didn't feel the need to bring the issue up with them or anyone in charge. Why didn't they speak up? The behaviour wasn't one time thing, and ongoing evidence in the logbook of them not following procedure, but no one felt like they had to do something about it. People were complacent about the breach of safety procedure, and it led to a disaster and two deaths. And why did the two operators feel it was ok to not follow the procedure? Were they not aware of the consequences? I know that sometimes people are told to do something and are told it's for the best, or their own good. But there is a lack of understanding of the actual consequences. Or they didn't think that anything could ever happen to them. So there was complacency on behalf of a number of people, and unethically, people weren't looking out for each other.

Such complacency is unethical, and its consequences, as evident from Harris's description of the explosion and its aftermath at Cooke Works, illustrated to Freya precisely why ethical conduct is essential not only at work but in everyday life. She has reflected as follows:

In everyday life, not only at work, but everywhere, it is important to conduct myself ethically. I'm interacting with people and the environment every day, and if one day I decide to do something unethical, I can damage the environment, or impede someone else's way of life, or upset their day. I don't have the right to do that. In everyone's personal, social and professional life they are interacting with people and the environment and if someone decides to act unethically then this can have major consequences. Sometimes the unethically conduct can also have ripple effects. People's

families could be affected by a boss unethically dismissing an employee. Or dumping waste incorrectly, but perhaps not illegally may not have immediate detrimental effects on the environment, but after heavy rain or decomposition, maybe then it will have an effect or may wash into waterways that go through natural parks. It is so hard to know the full effects or our actions, that why it is so important to conduct ourselves ethically in all areas of our lives.

In the above passage she has laboured at arguing that ethical conduct is vital because it is impossible to truly fathom the consequences of our own actions and the possible detrimental effects they may inflict on people and environments. Ethical actions are in themselves an essential step in the process of risk management systemically.

Chuck, like Freya, also realises the ripple effect of unethical actions. He believed that the Mold Crown Court's prosecution of the company was justified. Based on Harris's account, recognising the possibility of bias in Harris's description, Chuck also believed that the two operators were at fault because they wilfully chose to disregard plant procedures routinely and that Harris, or any company director for that matter, should not be fined or charged for the personal actions of fellow employees who choose to disregard policies and procedures that are established for their own safety and wellbeing.

The company was rightly charged, Chuck has described, because it was their responsibility to ensure that employees were following procedures correctly. He has stressed emphatically that someone should have noticed and that it was an issue of due diligence given the fact that those operators were cutting corners for as long as they were and others in the factory knew of it. To him the accident represents a systemic failure to act diligently, the outcome of a 'tangled web of responsibility' as he has referred to it below:

The incident becomes tangled in a web of responsibilities - those of the workers to stick to the procedures, that of the supervisor and plant manager to ensure that the workers stick to the procedures in place, and that of the director to ensure that the managers below him are on top of their workers with following safe and correct procedures.

For Chuck, Harris's account of the Cookes Works accident illustrated that ethical conduct is both a responsibility and an obligation and extends across one's personal, social and professional life. In order to argue this point Chuck has used two personal examples, with the first being hypothetical, as shown below:

> We all have an ethical responsibility in our personal, professional and social lives and an obligation to act ethically. Why? So we can earn our right to live in a safe, considerate and secure society, knowing that others are (hopefully) making ethical decisions for the good of everyone. As airy fairy as it sounds, it makes perfect logical sense. If I were to drive drunk down Canning Highway, it would be my own choice. BUT it wouldn't be the choice of other drivers to be put at immediate danger of my risky driving. Neither was it their families who'd potentially lose a son or wife or daughter, or the City of South Perth's, were I to damage public property while losing control of my vehicle. It is a personal responsibility which extends to a wider social responsibility, hence why your friends or authorities prevent you from getting in the car. Not to mention, loss of income for my family (if I have one dependent on me), grief, sense of loss and similar ripple effects. The connections we have to people and society become infused with a moral or ethical responsibility to do what is right, not just for ourselves but for the sake of greater society as well.

In the above statements, having furnished his first example Chuck has acknowledged that ethical conduct carries with it the weight of moral and social responsibility. To show convincingly that such ethical conduct is seriously pursued in the professional practice, Chuck used the second example as follows:

> As I've had work experience with an engineering company, I have been exposed to ethical professional practice. The company I worked for has a technical engineering contract with Chevron for the oilfields on Barrow Island. As Barrow Island is a Class A nature reserve, the care taken for environmental impact is always a high priority. There is a desire in all engineering work to not only comply with standards but give a reasonably, slightly over-conservative consideration in order to go above and beyond the environmental precautions already in place. All of us knew that it was a delicate system and this was reinforced in the Chevron online induction as

well, thus we felt ethically obliged to follow correct procedures and responsible for the safety of people and the environment on the island.

Chuck's examples suggest that he understood that issues of risk and safety possess a social and ethical dimension as well given that a breach in safe practices have consequences that extend well beyond environment where the breach does occur and affects far more people than those immediately involved in such a breach.

5.4 Student Responses to the Practice of the Commitment to Recognising, Appreciating and Including Multiple Perspectives

Systemic thinking is an epistemic approach to understand a complex, problematic, and ill-structured situation by constructing the richest story about that situation. It was stated earlier (see introduction of Section 5.3 above) that in order to develop such a story it is imperative to begin by including a perspective other than one's own. However, we soon realise that each perspective is "terribly restricted" (Churchman, 1968, p. 231). But this limitation is essential to the systemic approach because it compels us to sweep in as many available perspectives so as to "learn what everybody knows" (Churchman, 1968, p. 232). This is in essence what a systemic approach allows us to do: to realise the necessity of including and possibly integrating multiple perspectives as to understand what makes a complex, problematic, ill-structured situation so.

Safety culture is an ill-structured concept. It means different things to different people. The term is open to interpretation; it has been noted that some consider it to imply safety related attitudes and behaviour, while others contend that the focus should be on a constellation of safety related practices (Hopkins, 2006). The Systemic Thinking Session **in week 9** centred on the exploration of the notion of safety culture and its significance to process risk management. Both the sessional discussion and the post session reflective blog exercise retained that theme. The activities were opportunities to recognise the ill-structured nature of the notion. They were conducted on the assumption that the participants would themselves have different conceptions and preconceptions about it. Getting them to surface multiple perspectives would enable them to understand the necessity to examine and include various available perspectives thoughtfully. They could develop a richer, rounder, holistic understanding of the responsibilities, difficulties, tensions and limitations involved in maintaining, and

improving or changing safety cultures in the chemical and process engineering, mining, and oil and gas industries of which they would soon be part.

Through the two activities, the participants could, more or less, "learn what everybody knows" (Churchman, 1968, p. 232). The discussion required the session participants to organise themselves into groups of larger sizes than those in the previous sessions ensuring that the group members had diverse personal, cultural and professional experience. I had hoped that the deliberate emphasis on member diversity would yield a good mix of interesting views and dialogue on safety culture. The reflective blog exercise was meant to pick up where the discussion ended. The discussion was to proffer participants noteworthy issues and perspectives to contemplate in their respective blog responses. Participants were expected to pick up one or more of those issues discussed and subsequently develop a personal perspective that problematizes the chosen issue.

Participant Responses: Milo, Rex, Izzi, Keira, Paloma, Shireen, Dax, Yul, and Theo

This case centres on the responses of nine participants – Milo, Rex, Izzi, Keira, Paloma, Shireen, Dax, Yul, and Theo – to the reflective blog exercise. However, where possible, snippets of dialogue from the session discussion have been included in order to demonstrate that the conversational exchange between particular participants prompted their choice of issue for reflection.

The above participants attended the Monday session in Week 9. As is the nature of student engagement over the course of a semester, there was a significant drop in attendance owing to increasing assignment workloads, looming submission deadlines, and various class tests. Both my Monday and Tuesday sessions were no exceptions to the trend and saw participant numbers drop dramatically. The Monday session of week 9 had 41 participants, and those named above were some of them.

The participants self-organised into three differently sized groups with one being the largest of them consisting 20 members. Milo, Rex, Izzi, and Keira belonged to the 20-member impromptu team. Paloma, Shireen, Dax, Yul, and Theo distributed themselves into the other two groups. All of them were undergraduate students with vacation work experiences in one or more national and international engineering companies. They were, however, studying in different process engineering streams. Milo, Izzi, Keira, Paloma, and Theo were students in the chemical engineering course, while Rex, Dax, Shireen, and Yul were enrolled in Mining Engineering or Oil and Gas Engineering.

I have included snippets of their intra-group dialogue to support the reflections of the above four participants from the 20-person group. However, I have not provided the same for the reflections of the other five participants. The reason for this choice is as follows. Although I had recorded the entire session, for well over the first half hour I had deliberately handed over my digital audio recorder to Rex to capture his group's discussion. The decision to capture a discussion in progress was premeditated, but the choice of group was not. At the time, Rex's group were seated closest to me, and my decision to record their discussion was impromptu and very much a matter of convenience.

Consequently, I could not capture the intra-group discussions of the other two groups that were occurring simultaneously. The issues addressed by those two groups were not immediately available. This was subsequently remedied by the classroom wide discussion that followed the three intra-group discussions. It allowed many of those previously unavailable issues to re-surface. The interactive nature of the classroom-wide discussion between various members of all three groups made it difficult to explore those issues in greater depth. Moreover, the dialogue flowed quickly from one issue to the other, covering different perspectives along the way. Although it was possible to attend to this flow during the discussion, the fleeting exchanges cannot be rendered sensibly beyond that context. Bearing that in mind, I chose instead to present how Paloma, Shireen, Dax, Yul, and Theo responded to the issue to which various members of the three groups repeatedly returned.

I have chosen the reflections of the above nine participant partly because: (1) they were particularly active in exchanging their views during their respective intra-group discussions and the classroom wide discussion; (2) partly because they subsequently incorporated and elaborated those views in their reflective blogs; (3) and partly because I was able to develop a coherent narrative to demonstrate that various problematic aspects of safety culture were raised and reflected on as a result of both activities. Like those who featured in the previous case, these participants articulated their points of view in unique and personally meaningful ways. They successfully conveyed their personal 'reading' of the problematic aspects of safety culture and emphasised a different perspective when which taken together generate multiple perspectives as to what ought to be considered vital to safety culture and how maintaining, improving or changing safety culture is rendered challenging.

The group discussion yielded several issues such as assurance, compliance, liability, standards and codes, values, behaviours and attitudes, incentives and penalties, blame and responsibility, reporting and whistleblowing, and unfair practice and misconduct as issues of general culture as well as safety culture. For the present purpose, however, only four issues will be presented in turn. We shall, however, examine each issue as it was addressed by one particular participant in his or her reflective blog response.

By presenting as follows the nine participant responses to the reflective blog activity from Week 9 it will be possible to demonstrate in Section 5.5 below how these responses serve to suggest that the participants were activating their individual abilities to think systemically about safety culture.

Milo discusses the need for safety culture to be goal-oriented.

Let us turn our attention to the issue of aim or goal of safety culture. Our focus will be on ***Milo***, one of the participants involved in the snippet of interaction presented below:

> *Rex: Okay let's start with opinions…So do we see safety culture as an act that everyone practices every day without harm coming to the environment? Does anyone want to dispute that or agree with that?*
>
> *Liv: I think ideally that's what it is. But ultimately safety culture is an ideal. Ideally you can be trying to be safe and trying to make everything safe but that doesn't mean it's always going to happen.*
>
> *Milo: But isn't that the goal of safety culture as opposed to –*
>
> *Keira: Yea, you create a safety culture.*
>
> *Liv: You want it to be perfect.*
>
> *Keira: That's what you want to achieve.*
>
> *Rex: Essential element of safety culture?*
>
> *Milo: I suppose it's an essential element of safety culture to have an end goal, what you want.*

As shown above, Rex queried the group regarding a definition that was supplied by a member of their group. He sought opinions that either favoured or opposed it. An exchange of views ensued between Liv, Milo and Keira. Liv agreed that safety culture does involve acting safely so that no harm is incurred. However, she felt that while it is possible to act safely, the expectation that doing so would ensure no harm can ever come is misplaced. It must be recognised, as she has pointed out, that the concept of

safety is the ideal that guides safe practice and acting safely. A culture of safety requires the recognition that safety is a valued ideal that must be realised in practice.

Milo is quick to note the implication. Prior to the above exchange, when it was his turn to express his view on safety culture, Milo mentioned to the group that to his understanding a company's safety culture required a "mindset" toward safety in that all employees could have a productive work day and then safely return to their respective families. Acting safely would ensure that employees could come to work to earn their livelihood, and then use their off-duty time pursuing other life goals. To him, then, the notion of safety is both a goal and a motivation. But in the context of the brief exchange above, he believed it is primarily a goal. So when Liv suggested that safety is an ideal, Milo followed her to point out that another way to see an ideal is to think of it as a goal.

Keira interjected Milo. During the initial discussion, she had passed her turn as she had not formulated her thoughts on defining safety culture as she understood it. The remaining members had their turns, and Rex was the last member to do so. Keira responded soon after Rex, as she had thought of something to say by then. Keira told the group that in her view safety culture required "getting everybody on the same page and thinking about safety and creating safety culture so that everything you do there, everyone is thinking safety…it's just part of everything."

As Keira saw it, a culture of safety isn't just present but must be created. It is this very point that Keira reiterated when she interjected Milo. It supported the statements made by both the previous speakers in that only when safety is continually considered paramount and prioritised accordingly in practice that a culture of safety can truly be said to manifest.

Liv responded, having realised that an ideal meant something to be strived at, that safety culture must be perfected. Keira, then, immediately concurred that it is a state which must be achieved. Thereupon the above episode culminated with Rex asking if there was an element of safety culture in there and to which Milo responded by suggesting that having an end goal is an essential element for safety culture.

It appears that Milo was drawn to this brief exchange, for interestingly he chose to devote a part of his reflective blog response to elaborate on why he perceived having a goal was essential to safety culture. His introduction, as shown below, clarified his reflective blog response:

My thought process to conceptualise "safety culture" was to look at what made up safety culture, the aspects that effected employees and employers views on safety. I did this primarily through looking at how safety was dealt with at my current work place. I broke it down it to three areas that I saw as holding the framework for our safety culture. Those being the aim for a safety culture, motivation to act safely and method it was enacted.

Milo did not offer a definition of safety culture in his reflective blog. Instead he chose to describe what he perceived to be a conceptual framework by which the concept of safety culture could be understood. Experiences at his work place were instrumental in the formulation of that personal framework. As he saw it, this framework entailed an aim for safety culture, the motivation to act safely and a method by which both the aim could be realised and motivation channelled.

Milo then described each of the above to demonstrate how he understood them. On having an aim for safety culture, he said:

The aim for any safety culture as I saw it was the end state for a safety culture, where everyone wanted to end up. Ideas of this are in programs such as zero harm where the company is aiming for no injury or lost time this also covers the aims of workers. To some extent the aim for me, can be seen as the companies perspective, aiming for low injury figure whereas the employees aim is generally more qualitative and for me cover more by motivation.

For Milo, safety culture is not without purpose. If, as his discussion with Liv, and Keira above had illustrated, safety culture is an ideal or goal to be pursued, then necessarily it involved asking the question: To what end or purpose must safety culture be pursued? It is important to consider that "end state", as he put it. Where was it that everyone – the company and its employees – "wanted to end up"? The aim of safety culture would likely provide an answer to such a question.

That Milo was attuned to the discussion regarding the goal of safety culture is most strongly demonstrated by his explicit reference to the notion of Zero Harm. Shortly after the interactive exchange between Rex, Liv, Milo, and Keira, there occurred the following sequence of dialogue between Meesha and Rex:

> *Meesha: I did my vacation work at [Name of a multinational engineering company] and their kind of general idea is Zero Harm and it flows into everything, so environment, people, business…Zero Harm.*
>
> *Rex: So would that be a goal?*
>
> *Meesha: I think that's a goal, yeah.*

The group discussion had just yielded the idea that the presence of an end goal for safety is an essential element of safety culture. Rex asked the group how such an end goal is possibly realised in practice. Meesha responded by making a reference to her vacation work experience with an engineering company whose safety motto is Zero Harm and how that motto is pervasive both in the work culture and working practices of that company.

As is evident from Milo's description above on the aim for safety culture, Milo recalled this episode of the discussion and used Meesha's example of Zero Harm to illustrate how such an aim is to be practically implemented. The aim of Zero harm, as he put it for example, meant implementing safe practices such that no injury or lost time is incurred. However, as he has pointed out, he felt that it is more sensible to consider an aim as that which a company establishes. A fitting equivalent from an employee perspective is motivation, the next constituent of his conceptual framework. On the matter of motivation, he explained as follows:

> *Motivation is why people want to be safe looking more at the employees in the system. Motivations are anything from want to be able to go home to your family to wanting to play football on the weekend. Motivation for me from what I have seen at my work place covers not only why you act safely, but also why come to work at all in the first place.*

The above comment strongly echoed a point he had made during the initial discussion between the various group members. In it he had emphasised that to him safety was both goal and motivation. His description above about the aim for safety culture related directly to the notion of safety as a goal, while the subsequent description clearly emphasised the latter aspect of safety as motivation.

Method, then, related to how a culture of safety can be enacted, and it is the third constituent of Milo's framework. In his reflective blog Milo wrote briefly that method meant "how the company and employees carry out their safety culture message". According to him, the charge of operationalising a safety culture rests with both the

company and its employees. He realised this relationship as a result of his own work experience. He admitted:

> Before I went out into the real world I would have considered this the area and responsibility of the employer and it would be the way they make people act safely, however since being in the real world it's quite evident safety is not something that can be enforced it has to be willingly participated in [otherwise] the safety system and culture will fall apart.

Milo's work experience was revelatory in at least two ways. Firstly, he realised that the creation and maintenance of a culture of safety is a collective endeavour involving both the company and its employees. Secondly, a culture of safety must be participatory if it is to succeed in remaining intact.

To illustrate that such a framework is indeed practical, Milo proceeded to describe a personal example. He had only fleetingly mentioned this example during the discussion with his group mates. However, and fortunately for our foregoing examination, he elaborated on it in his reflective blog response. He explained a system from his workplace called Perfect Day. The phrase neatly captures the prevailing safety culture. He wrote:

> At my work we use a system called perfect day. [It] is really the safety culture in a neat little phrase. It encompasses all the parts that I consider to be the framework for a good safety culture. Firstly aim: the perfect day is the aim for the company. [I]t is a day of full production where no one gets hurt or misses time from work, for the employee it is a day where they get to still do what they love at the end of the day. Perfect day is also the motivation it is why people go to work and why they act safely so that they can continue to do what they love and have more perfect days. The method part may be a bit of a stretch but it still fits in the mantra of perfect day. Perfect day is also how the safety culture is enforced and carried on. By getting everyone to constantly think about why they are at work it "forces" them to act safely. Not a literal force but internal force that says "hey I want to play footy on the weekend so I'm not going to try [to] lift that beam by myself" this is the key to a good safety culture for that internal motivation to act in a self-preserving way.

Milo's example conveyed his framework accurately. He related the phrase as the aim of the prevailing safety culture at his workplace as well as the motivation to act safely. Then he covered how the notion of a perfect day is enacted so that safety became, as he later put it, "an intrinsic part of the day to day at my work".

Rex reflects on the influence of the concept of family on the integrity of safety culture.

We turn our attention now to another issue that emerged from the group discussion – the concept of family. This time, however, our focus is directly on **Rex's** reflection on this issue. Rex has recounted what he picked up during the discussion. By doing so, he has provided us an opportunity to skip the actual dialogue itself and to directly attend to Rex's interpretation instead. Rex wrote:

> *A common point from past discussions with classmates is that a safety culture is meant to foster the concept of family within the company. One argument put forward is that full time (40 hour week) employees will spend at least 24% of their time per week at their workplace. By stimulating this notion of family, the company generates a more supportive environment for the employee, increased safety vigilance across the company, and higher employee retention with lower personnel related incidents. On an external level, the surrounding environment also benefits, as well as the company itself by society perceiving itself to "be good for the community".*

In the above comment Rex has foregrounded the concept of family and its implication for the sustenance of safety culture. As he has reported above, the group discussion led to the idea that "family" was an alternative way of interpreting workplace relations which lent itself readily for the maintenance of a company's existing safety culture. Such a perspective brings related benefits such as "increased safety vigilance", "higher employee retention" owing to lower rates of incidents involving work personnel, and possibly even an improved company reputation in regards to safety at the workplace.

Having introduced the matter, Rex then proceeded to examine its underlying assumption as shown below:

> *Why is the concept of family so important? Taking a philosophical rather than a psychological stance, family can be taken as that which defines a person. From the moment we are born we are raised with others, in a "family". We grow up and stay with the same group of people for a very*

large portion of our lives. By using this concept in companies, the chance of employees taking to heart all the discussions about safety, and strive to protect their fellow workers is increased. Increased safety is not the only benefit. Increased productivity can also be logically expected, as well as higher employee retention.

As is evident above, Rex recognised that the concept of family was used analogically to emphasise a relationship between individuals that is sustained over a period of time. He then clarified how the analogy applied in relation to a company's safety culture. As he stated earlier, full-time employees that are likely to work approximately 40 per week spend a significant part of their time per week together in each other's company. Accordingly, it would be reasonable to assume that the employees constitute a workplace family. Invoking a familial bond in relation to safety culture meant that there is an ever present impetus to all employees to engage in safe workplace behaviour, conduct, and practices so that no harm comes to any work mates. Such an impetus is by nature personal, social and ethical. Owing to its presence, one could then logically expect increased workplace and personnel safety as well as increased productivity.

Rex continued:

I was given a good example of a family concept when I was on an IChemE course. On one processing plant in particular, management noted high employee retention and a high rate of incidents in one shift rotation compared to another, which exhibited low incidents but a normal retention rate. The investigation found that the safety culture in the second shift was average, nothing worthy to note. The first shift however, was found to have developed a camaraderie, through one burly Egyptian operator who would take half a day off every week to cook a large signature dish for the entire shift rotation at the end of the week. Due to the absence of the operator, incidents naturally occurred, but due to the unusually strong family feeling, the shift would be extremely efficient at working together to mitigate hazards.

It was clear to Rex that there is merit in applying the concept of family to safety culture. To emphasise his perspective Rex offered an anecdote which he picked up while attending a safety course administered by the Institute of Chemical Engineers (IChemE). The anecdote is succinct and self-explanatory. Although it conveyed exactly what Rex

wanted to highlight, there was another point waiting to be made. Following the anecdote, Rex wrote:

> *The point I'm trying to drive home here is that a strong family safety culture is great, but needs to be supplemented with other notions to prevent scenarios like the above occurring. A theme that emerges with family is that of responsibility. Responsibility is something that the employee must be constantly made conscious of, not only for themselves, but for others, the company, and other assets.*

Rex had grasped that a strong familial safety culture is effective only if it suitably invokes a deeper and heightened sense of personal, social and ethical responsibility amongst employees toward each other and their company. Furthermore, it is imperative that this sensibility be continually strengthened.

Izzi and Keira highlighted the importance of education and training to counter the influence of unsafe behaviour and practice

Responsibility for safe behaviour and workplace practices came up as a topic for discussion. Several group members agreed that this responsibility must be shared by a company's management and its employees. As the discussion progressed, the group found itself conversing about workplace behaviours and its role in practically incorporating the philosophy of inherent safety in design and operations activities.

There was awareness that safety must be embedded into every aspect of a company and that for this to occur safety must be a part of the routine thinking process rather than an after-thought. There was an implicit understanding within the group that human factors played a critical role in safety system failures owing to uncertainty and unpredictability of human actions.

The only way to increase the likelihood that the right behaviour will occur is to ensure that all employees of a company have access to on-going safety awareness and education. The snippet of interaction shown below dealt with this specific issue. Our focus here is on the views of two participants, **Izzi** and **Keira**. It must be noted, however, that Keira does not feature in this particular verbal exchange between Izzi, Liv, and Rex, presented as follows:

Izzi: I think you must have on-going education as well because, I know where I did my vacation work, when we first started we did like lots of inductions and safety was drilled in our head and we were all like "Yea, yea, safety", and then we got out to work and we'd been working for about a month and a half and there'd be people who'd been there for like 15 years. So they would walk around without their safety gear on and you get used it. And you'd be like "Oh well, if they've worked here this long, why should I wear my safety gear". Like you know? You'd see that and you'd be influenced by it. Those people –

Liv: Probably need training.

Izzi: Those, those, people need to be constantly trained so that they don't start doing unsafe things and influence others too.

Rex: So awareness and re-education.

Izzi: You just need to keep re-educating people otherwise they get complacent.

It is clear from the above verbal exchange that *Izzi* strongly felt that education and training were vital to instil awareness, recognition and ownership of safety responsibilities. However, what is interesting here is her emphasis on the fact that it be ongoing and inclusive of veterans. To emphasise her point of view to the group, she recalled her vacation work experience with an engineering company. Numerous inductions gave her a sense that safety was foremost. However, it turned out that the actual experience of working on site conflicted with the messages and impressions she had received. She had noticed that there were on site senior employees who chose to neglect safety instructions. She felt that such employees, given their experience and seniority, could easily influence others, particularly newer, less experienced staff, to flout safety protocols and that it was acceptable to do so.

Izzi re-emphasised her perspective on ongoing education and the inclusion of veterans in safety educational programs in her reflective blog. As she saw it, "constant education and good leadership are vital to promote a safer workplace". To her, it was imperative that ongoing safety education programs include veterans because they are leaders and role models in relation to workplace conduct. When they demonstrate good safety practices, Izzi noted, they are "more likely to persuade newer workers to implement the safety ideals they have been taught at inductions."

Re-iterating a point she stressed at the end of the snippet above, Izzi wrote:

By continually educating workers on the required safety for their particular

workplace and constant re-teaching of this, is the only way to keep safety

fresh in their minds. People become complacent and lazy very easily. Continually reminding people of the hazards is one effective way of making sure safety standards are upheld.

According to Izzi, if safety in the workplace is paramount, then such an emphasis can only be conveyed through educational efforts. She realised that continual education and good leadership are vital for changing mindsets if the philosophy of inherent safety is to be practically embedded day-today company operations.

Keira, a group member listening to Izzi's perspective, was very much in agreement. She had not offered her own view on the subject when Izzi, Liv and Rex exchanged words. However, she addressed it in her reflective blog in relation to how the philosophy of inherent safety can be practically implemented. Keira wrote as follows:

We discussed that through education, and continual re-education, safety could be incorporated into every action and decision, to discourage the mentality that safety is just something extra to do, an inconvenience, time consuming. Inherent safety is a strong indicator of safety culture, in fact we believe you cannot have safety culture without it.

She then recalled an experience from her recent vacation work experience to support the above statements:

While I was working at [Name of Company] over the summer, it was interesting to witness the attempt by management to implement a better safety culture in the workplace. The extent to which operators employed safe working practices had a lot of room for improvement. Acid burns were frequent, and the use of PPE was fairly relaxed in the case of some operators. The way the management approached the implementation was through education. This consisted of external courses for particular practices such as working at heights and confined spaces, as well as an overhaul of internal procedures which required much retraining. This demonstrates the approach of obtaining inherent safety through education.

While Izzi's experience revealed the need for education, Keira's experience corroborated that education was certainly a worthwhile strategy to bring about a workplace cultural shift. Keira's vacation work had exposed her to the fact that when undertaken correctly educational efforts are indeed quite effective in countering unsafe workplace conduct.

She had observed that operator practices at the work site were shoddy. For example, as she has mentioned above, incidents such as acid burns were frequent, as was the lack of regard for the use of proper personal protective equipment (PPE). The company's management strategy to counter this situation was to educate operators in an attempt to shift their mindsets toward safety. They provided access to and mandated externally administered safety courses for specific risky activities such as working at heights and in confined spaces, and also invested in retraining staff when alternative procedural changes were effected. This experience demonstrated to her that education can indeed effectively combat unsafe workplace conduct.

Paloma, Shireen, Dax, Yul, and Theo problematized the issue of perceptions, values, and priorities that constitute safety culture.

The workshop participants were in agreement about one particular aspect of safety culture. It was that human factors make or break safety culture. Participants wholly accepted that it was imperative to strive toward a "good", "positive", "strong", and "robust" safety culture rather than one that is "bad", "negative", "poor", and "weak". This difference in qualities was largely a reflection of the degree of importance attached to safety. Many participants chose to explore in their reflective blog responses one or more factors that lead to the above qualitative differences in safety culture.

Paloma, for example, remarked that although she had found multiple definitions for safety culture on the Internet, there was one in particular which she thought captured some of the universally accepted core components that would lead to a successful safety culture. To her, safety culture meant the way safety is perceived, valued and prioritised in an organisation. It demonstrates a real commitment to safety at all levels in the organisation.

Paloma chose to highlight the importance of commitment to safety in order to maintain a strong safety culture. She wrote:

> *As the definition also emphasizes, the commitment to safety should be apparent at all levels in the company. If people like the CEO and other supervisors do not share this commitment, this will reflect throughout the organisation. A company with a strong safety culture works as a team to enforce and promote the importance of safe practices. In this environment, people will be reminded more frequently of the risks involved and the*

measures they must take to prevent them. If a company has a strong safety core, employees will feel confident about maintaining safe work practices even if it will require the company more time and money to do so.

From the above comment it is clear that Paloma understood the significance of having and enacting a commitment to safety. Although she has noted that the commitment must exist at all levels of a company, it is of utmost importance that the commitment be most clearly visible at the higher levels of company management first. Only then can the same commitment percolate through to all the lower levels of the company. When safety is perceived, valued and prioritised as integral to business operations by the company management, there is a greater likelihood that it is taken seriously by the rest of the company and suitable enacted through safe practices. Paloma, however, was not alone in making the above assertion.

Shireen, like Paloma above, concurred that company management plays a significant role in how safety is perceived and practised. She defined safety culture as a general attitude to safety shared, evaluated and put into effect by all levels of management, from corporate executives to managers and operators both on- and offsite. However, management bears the responsibility to embody and enact the culture of safety it envisions. Shireen stressed this point in a metaphoric vein as follows:

In some ways safety culture is like flora planted by management in the empty soil of a purely production-focussed facility. The flowers of safe attitudes and practices are alien concepts which must be sown, germinated and nurtured. Although they may remove some of the value from the soil by detracting from production goals, the flowers of a good safety culture actually add net value to the site. Management choose the type of culture, then sow the seeds by defining and communicating a broad attitude towards safety in the early stages of a project and by putting in place mandatory safe behaviours and safety assessment tools when the site is being established. They must then foster a good environment for the culture to grow. For example, they must encourage an environment which rewards safe behaviours, punishes unsafe behaviours, has a good reporting culture, encourages employees to voice their concerns and, crucially, both listens to and acts on those concerns. They must be proactive in eliminating known hazards and trying to anticipate unknown hazards.

Shireen's horticultural analogy and use of related metaphoric phrases heighten her emphasis. The image she has conveyed above is that safety culture ought to be cultivated. Safety attitudes and practices do not necessarily exist as such but if they are to emerge then the appropriate "seeds" must be "sown", allowed to "germinate", and then "nurtured". These responsibilities rest with company management, for they are in a position to conduct such activities. Once they have settled upon a safety vision and adequately defined it, the task of communicating and enacting it also falls to them. They ought to ensure that a culture of safety is activated through appropriate processes, practices, policies and provisions.

Although it is clear that company management plays a critical part in cultivating safety culture, it must also be acknowledged that this is not always the case. When this happens, it leads to what Shireen has referred to as the "active degradation" of safety culture. According to her, active degradation of safety culture may occur when individuals are actively encouraged to take unsafe shortcuts in order to meet production targets, or where certain individuals actively resist safe workplace conduct and expectations. At times, management may perpetrate such an active degradation of safety culture when it fails to do what is necessary in an attempt to avoid the "costs of creating this culture".

The reality is that company management can be resistant to the investment involved in establishing appropriate processes, practices, policies and provisions. This issue was specifically highlighted by **Dax** in his reflective blog response. Dax developed his perspective based on an article authored by Simon Gakhar, a process safety consulting engineer who presented a consultant's view of how to raise the priority of investing on safety with the financial departments of companies (see Gakhar, 2012). Dax recapitulated Gakhar's article as follows:

> *The article gives a good insight into the viewpoints of company directors in relation to safety culture gathered from Gakhar's years of experience in dealing with them. The way he responds to the challenges and reactionary attitudes he faces give the reader a way of convincing a manager the extra spending is worth it. A year after an initial visit to a site and a raft of recommendations being made with particular deadlines for completion being drawn up and agreed to, a revisit to the same site often shows that only the cheap and easy recommendations were carried out. Often this is to*

do with why the consultant is there in the first place – namely because an internal drive to improve safety culture has failed.

Following Gakhar, Dax wanted to introduce the idea that while it may be well for us to assume that company management ought to be proactive toward adoption of safety culture oriented processes, practices, policies and provisions, in reality management can be reactive and short-sighted. The real challenge for process safety experts, especially external consultants, is to convince management of the benefits of investing in safety and guiding them toward appropriate courses of actions.

To Dax, management resistance to investment in safety is simply a symptom of a far deeper problem. He explained his view below:

Simply hiring an outsider to propose a new set of recommendations is not going to change the mindset of the employees. Clients try to simplify the problem, requesting the safety issue be summed up in three or four key actions. The complexity of the working lives of managers means they wish to prioritise rather than spend. Often prioritisations are difficult and in the end most or all of the issues presented are given a very high rating leading to unrealistic outcomes.

The problem, as Dax has identified above, is the management mindset. One must bear in mind that often an external process safety consultant is hired only when the attempts of the in-house safety expert have been less successful in convincing management about process safety improvement expenditure. However, as Gakhar's article has pointed out, even external process safety consultants court similar failures. Although it may be argued that neither the in-house safety expert nor the external consultant used effective methods of communication with management to convey the significance and merit of needed improvements, the difficulty truly lies elsewhere. One cannot fully rule out management's adamance on safety matters. As Dax saw it, a managerial mind is educated to simplify and prioritise managerial problems and safety issues tend to get resolved by investing on cheaper options rather than the ones that are likely to bring most benefit.

Expending on safety improvements is hindered by the difficulty to demonstrate the benefit of those improvements. Accidents cost money, and major accidents are exorbitant. Process safety improvements, however expensive, are aimed at dramatically

reducing the likelihood of major accidents. Such improvements save far more as a result of the investment, than would be lost in the event of a major accident, had it occurred in their absence.

The irony here is that it is easier to calculate the losses incurred after a major accident than to demonstrate the gains achieved by making the necessary safety improvements that may likely avert a major accident in the first place. This irony can be lost on a managerial mind trained to expect immediately visible effects as a consequence of investment. Such expectation is detrimental in relation to expenditure on safety improvements because the "immediate benefit of reducing risk cannot be easily measured in terms of return on investment" (Gakhar, 2012, p. 32).

The real challenge, according to Dax, is changing such a mindset for the better; to shift attitudes so that safety is seen and understood as vital for successful and effective business operations. The crux of the underlying problem, Dax has asserted, is that "management has misconceptions about safety".

Dax is right. According to Gakhar (2012), the phenomenon of misperception regarding safety in the chemical and process industry is very real. He has pointed out that there is still a poor perception of the potential consequences of major incidents such as explosions or runaway chemical reactions. More often than not such perception is grounded in disbelief that certain hazardous substances could ever be "all that dangerous" and in the misplaced belief that an incident "couldn't happen here".

However, it is not management alone that succumbs to the above affliction. Other employees that constitute the company workforce can also to be included. *Yul* brought this point to light in his reflective blog response. According to him, when it comes to effecting a change in safety culture, one must realise that the workforce has its way of operating and its own way of getting things done. This is an escapable fact owing to which, as Yul has pointed out:

> *Cultural changes are difficult to make. They do not happen overnight and cannot be done forcefully, where they will often result in disagreement, angst and even violence. People can be eased gently into cultural changes. Safety culture can be modified but it takes a long time.*

For Yul, what is true for cultural change in general is equally true in relation to a culture of safety. Safety culture related changes are bound to produce reactionary attitudes and

behaviours. Often the reactions are an immediate consequence of the discomfort associated with changes that upset the way things have been done so far. It unsettles what has become routine behaviour. Yul's point here is that change makers need to acknowledge that while change to an existing safety culture can be effected, it takes time for the change to truly become effective.

It is people, not time, that prove to be the challenge. Again, at root, it is an issue of effecting a change in mindsets at large. Yul wrote:

> *People whom have been working in the same company for extended periods of time can act as inhibitors to change, word vomiting terms such as "We've always done it like this," "Nothing has gone wrong so far" and "if it ain't broke, don't fix it." These change inhibitors are difficult to overcome, especially at ground level operations where people may not have the background to understand the engineering and workplace safety laws and regulations intentions and improvements.*

As can be seen above, those with several years of experience in operations predictably attract much of the attention. Their experience of working in the same hazardous environment for extended periods of time habituates them to certain behaviours. It tends to normalise their risk taking propensity.

But, as Yul continued further, new employees or those with much lesser experience than industry veterans must not be overlooked as change inhibitors. However, their reactionary attitude may be motivated by quite another reason, as Yul explained:

> *Inhibition to change is not limited to older, experienced workers; new employees can also rise against positive cultural change if they perceive a negative facet in relation to their own activities or privileges. A perfect, real world example is no more fishing while on-site in remote areas, as the risk of injury associated with fishing (i.e. slips on rocks, fishing hooks) can be eliminated by people not participating in the fishing altogether. This is an actual example taken from a previous mining boss of mine when he was relocated to the Koolan Island iron ore facilities on Australia's North-West. Needless to say, the isolated mine workers were not happy about this change to their recreational activities, which they perceived as a non-issue*

> *when it came to mine site safety, especially as they were doing in their own time with their own money.*

Yul recalled an instance of how mine workers reacted when a company policy was put into effect that disallowed them from engaging in recreational fishing during off-duty hours. Those miners felt the policy was curtailing their personal freedom in the interest of safety and that this justification was misplaced. From the mine workers' perspective, their reaction was understandable, since the mine workers were indeed fishing in their own time, with their own money, and away from the mine site. To them, perceptibly this made it a clear "non-issue" because their actions would not directly affect mine safety.

But those mine workers were not seeing the bigger picture. They were not including the company's perspective. Yul highlighted the company perspective as follows:

> *In fact, they were still under the responsibility of the mining manager, even when not 'on the clock' and this could be seen at the justification for these changes to safety. From this we need to look at the principal; there was a hazard that could be eliminated and was. This is good practice in hazard minimisation.*

To Yul, the policy was sound. Maintaining safety on and around the mine site was important. This included the safety of the mine workers too, irrespective of whether the mine workers were on or off-duty. Recreational fishing was not without risks. Realisation of those risks would not only affect particular mine workers, but it would also directly affect mine site operations as well. To the company, such risks were not acceptable. It was well within the company's interest to secure the integrity of their mining operations on the island, to maintain employee safety during on and off-duty hours, and to avoid the potentially harmful consequences of employee off-duty recreational fishing. From a company perspective, their policy of no recreational fishing aimed at making both the mining operations and the mine workers stay on the island as inherently safe as possible. It was, indeed, as Yul rightly asserted, an instance of the company demonstrating "good practice in hazard minimisation".

While the above instance highlights how proactively mine workers' safety on site was perceived, valued and prioritised by company and mine site management, it also highlights another more important point concerning safety culture change. According to Yul, it was:

A perfect example where change has been made, yet culture has yet to catch up. A change to procedures and rules does not invoke a positive response, that's not what changing for the better is about. It is up to the workers to take it upon themselves to put aside their personal views and look at the concept of making everyone's experience at work as safe as practical.

Yul realised that in the above instance mine workers' reactions inhibited them from fully appreciating their company's due diligence on safety matters. While it is reasonable to expect such reactions to arise, thoughtfulness on the part of employees could have alleviated the sense of discomfort than comes with positive safety culture changes.

Having reacted as they did, those mine workers failed to realise that the company had acted in the interest of personnel safety. However, more importantly, the mine workers had failed to realise their own responsibility and complicity in "making everyone's experience at work as safe as practical". Instead of being inclusive of perspectives other than their own, they were exclusively privileging their own.

Such a difference in attitude and actions in relation to safety, it seems, is even more pronounced if we were to examine cultural differences in how safety is perceived, valued and prioritised. **Theo's** reflective blog response centred on this dimension. Theo, an international undergraduate student from Indonesia, chose to highlight his personal observations about how differently safety culture is valued and operationalised especially during an economic crisis. He had worked in two different industries in two different countries. The first one was in a beverage production industry in Indonesia. The second experience was in steel manufacturing industry in New Zealand.

While on his internship in Indonesia, the beverage processing company was experiencing an economic crisis. In an attempt to cut operational costs where possible, the processing facility suspended the use of its forklifts. Factory workers were required to carry heavy boxes of bottled water manually over to the loading bay. To Theo, this seemed a particularly poor company decision because it unfairly and immediately exposed the workers to physical injuries that could result from heavy lifting, slips, trips, and falls. However, the company persisted with the decision, accepting the risk of physical injury to its factory employees as less significant than the savings made by cutting the operational and maintenance costs of using forklifts.

The decision reflected poorly on how little personnel safety was valued. This became all the more clear in relation to the company's response to the Indonesian governmental regulatory initiative called "Zero Risk". The zero risk initiative had incentivised industrial safety. It aimed at awarding and recognising companies with the lowest reported accidents. The company that Theo had interned with was trying to secure the award unethically. Minor incidents were ignored, while accidents were underreported so that the company could be portrayed favourably in safety ratings. Such conduct left Theo with the impression that the company largely undervalued safety and possessed a mindset fixated on compromising safety rather than improving it.

Theo's experience in New Zealand, however, was very different. He had worked for a company that produced steel rods. Each rod was given a unique identification number. This number was imprinted on each steel rod at very high temperature. The process was automated by the use of a robot. This innovation, however, was introduced with safety in mind because previously the same operation was undertaken manually, as Theo explained as follows:

> *The interesting part of this improvement is that the idea came up when the company suffered from economic crisis. The idea came up after one of the employees got a light burn after numbering the rod which has at a high temperature. The manager said it was fortunate that the employee only suffer from a light degree burnt, it may lead to higher level of burning in other cases despite the fact that this is the first case in 10 years after the system was first implemented in the company. It was very impressive to me how they paid attention into various small things that may lead to accidents.*

While working at the Steel rod manufacturing facility, Theo had learned that what was then an automated process using a robot was once a manual activity. On one occasion, one of the personnel received a light burn while numbering the high temperature steel rod. Although that employee had suffered a minor burn, the incident was duly reported and it alerted the management that such occurrences were likely and other employees could succumb to similar, if not worse, injuries as a result of the numbering process.

Management noted that the incident was the first time in ten years since the numbering process was setup. They did not, however, ignore this statistic. The risk to personnel safety posed by the manual numbering process was unacceptable. The idea of

automating the process using a robot was considered and the innovation was introduced despite the fact that the company was coping with an economic crisis.

To Theo, the difference in response to incidents involving company employees was undeniable. The Indonesian company he had interned with accepted risk to personnel safety and was willing to compromise the quality of its safety culture when facing tough economic times.

The company in New Zealand, however, was unwilling to jeopardise personnel safety even during an economic crisis. The contrast in how the two companies responded to safety highlighted to Theo that the practice of safety culture varies across different countries, particularly those that are considered as "developed" to those which are "developing".

5.5   Systemic Thinking in Action: Concluding Discussion

In competence development using an activity based approach what is learned is always complexly problematic (Illeris, 2011a, 2009d; Lave, 1996, 2009). This is attributed to the situative and constructive nature of learning that underpins it. The situative aspect directs our attention to the fact that participants view their learning situation in very different ways and attend to different particularities of that situation from one another (Greeno, et al., 1996; Sawyer & Greeno, 2009; Shuell, 1996), while the constructive aspect directs our attention to the fact that participants attend to different particularities of that situation from one another because they interpret the situation in a way that is personally meaningful (Mezirow, 2009; Sankey, 2007; Wenger, 2008). Owing to these two aspects, as McCormick and Murphy (2008) have noted, for any learning situation involving a certain task what the student sees as salient can vary and these differences in views of salience consequently influence the meanings ascribed to those views. Below we shall see how the participant responses for each of the two tasks from the previous subsections serve to confirm the above statements. It will enable us to appreciate how in responding in such unique and personally meaningful ways the participants were thinking systemically in relation to the two tasks they were set. Each set of cases is treated in turn.

First we shall attend to the responses featured in Section 5.3 above. In Section 5.3 above, for example, Dell, Noam, Carrie, Ken, Freya and Chuck, all of them, used Harris's (2004) account but in different ways to highlight different yet related ethical issues. The

facts, as made available in Harris's description, were the same. However, as the responses clearly demonstrate, they were organised or prioritised in different ways. Their responses are evidence of what they considered salient in that account and proceeded to express their point of view regarding that salient issue. Although the cast of characters were the same – the operators, the other staff, the factory management, and Harris – their actions and consequences of those actions were explored differently. It led each of the six participants to develop a unique and personal perspective.

The participant responses in the above instance are indicative of the activation of the situative and constructive aspects of learning involved in attempting to understand and respond to the learning activity in general and the task in particular. Furthermore, the participants were using their funds of knowledge to guide their reasoning and to communicate their point of view to their respective group members, where by funds of knowledge I mean such things as "their books, their ideas, their interests and experiences" (Moll, Tapia, & Whitmore, 1993, p. 161). For example, Noam used his previous experience of learning business ethics, Carrie compared her experiences of casual work at the nursing home, and Chuck drew upon his vacation engineering work experience.

Although their responses centred on some characters more than others, inevitably and more importantly, the participants directed their attention toward the relationships and interactions between those characters. All six of them, Dell, Noam, Carrie, Ken, Freya, and Chuck, some more explicit in their acknowledgement than others, were able to identify and appreciate that ethical issues emerged from such relationships and interactions.

This attention to relationships and interactions is a vital feature of systemic thinking as an approach to understanding an ill-structured situation such as the one depicted in Harris's (2004) account. In being able to examine the Harris account with the above emphasis these participants were illustrating their ability to put systemic thinking into practice in understanding the incident at Cookes Works.

From a systemic thinking perspective, by exercising their critical self-reflexivity, these participants were able to appreciate how the social climate and cultural constraints of the Cookes Works factory were partly responsible for facilitating the breach of procedures that eventuated with the death of two operators.

For example, Dell surfaced the notion of the 'old boys club' and its relation to possible managerial oversight, Freya highlighted the impact of workplace complacency, and Chuck deduced the breakdown of the 'tangled web of responsibilities' which amounted to what he considered as systemic failure. The participants were able to identify how the risk at Cookes Works was socially constructed.

They were consequently able to detect the complicity of actions and consequences of various risk players. They identified that various employees were, through their action and inaction, imposing risks upon all at the factory as well as the company. Ken's analysis is most illustrative of this fact in that by focusing on the interactions between various risk players he was able to draw attention to the complicity of the operators, other staff, and the factory management at Cookes Works in facilitating procedural breaches.

When critical self-reflexivity is exercised in the study of a risk situation, the focus is on examining the assumptions and premises that underpin the perception, understanding and judgment of those involved in that risk situation. The six participants were, in their own unique way, being critically reflexive of the risk situation as described by Harris (2004).

For example, both Dell and Noam correctly inferred that the two operators and the factory management diverged in their understanding of what constitutes ethically responsible work behaviour, and that it was likely that these differences led the two operators to impose risks by acting as they did.

Carrie's examination led her to infer that the operators in particular may have assumed incorrectly what their duties and roles required them to do, and this possibly led the operators to erroneously believe that it was perfectly normal for them cut corners or that the risks imposed by frequent canteen visits or the removal of nitroglycerine when a batch was in process were negligible compared to the benefits derived. The operators may have incorrectly assumed that the probability of an explosion is low, and nothing would ever happen to them.

Freya, for example, inferred that given how other factory staff knew about the risky behaviour of the operators and then possibly proceeded to take no substantial actions to correct the two operators implied that the factory staff also assumed the operators' actions were unlikely to expose everyone to severe consequences.

In chapter 3, it was pointed out that from a risk management perspective, to meaningfully understand how risk roles interact, what consequences result from such interactions, and how the relations and interactions may be better managed is tantamount to thinking systemically about such a risk situation. The responses by Dell, Noam, Carrie, Ken, Freya, and Chuck strongly suggest that in their own unique ways these participants were successful in understanding how the risk roles interacted, what consequences resulted from such risk roles, and how those role oriented relations and interactions could possibly have been better managed particularly in relation to Harris's (2004) cautionary tale of responsibilities for safety.

The fact that they approached the task very differently is to be expected given the situated and constructive feature of the learning situation itself. As McCormick and Murphy (2008) have recommended, such variations in responses must be accepted given the dynamic and ill-structured nature of the task, and possible interpretations based on each participant's interest, motivation, and the kind of personal funds of knowledge that are accessed. These constitutionally give rise to differences in salience that the participants deem as being critical.

Despite such variations, in responding as they did to the task embedded in the reflective blog exercise these participants showcased their ability to contemplate and communicate the ethics of safety and the responsibilities that come with it. More specifically, in relation to the intended outcomes, each of the participants discussed the ethical considerations they perceived to be implicated in that descriptive account and subsequently reflected on why ethical conduct is essential to everyday personal, social and professional life. By engaging as they did in this activity, which necessitated putting the first commitment into practice, these six were developing their ability to think systemically about that ill-structured problem.

Next we turn to the responses featured in Section 5.4 above. The discussion that week provided the participants an opportunity to think holistically about safety culture. Several related issues emerged in the course of the discussion, and various participants took the opportunity to express their views on the subject. The discussion was founded on the premise that the participants' preconceptions and beliefs would naturally prove conducive for dialogue.

The general motivation in conducting the discussion was that getting participants to express their views in the discussion would likely enable participants to realise that a

topic such as safety culture can be holistically understood when multiple participants' perspectives are integrated. However, the interactive and fleeting nature of the discussion limited the possibility of deeply exploring numerous issues that had emerged. Issues were raised or highlighted, but their examination was done cursorily.

But the discussion proved useful for the process of reflection despite the above limitation in that it gave participants one or more key issues and noteworthy viewpoints to contemplate. It is here that the situative and constructive aspects of this learning activity become most apparent.

Milo, Rex, Izzi, Keira, Paloma, Shireen, Dax, Yul and Theo, all of them, reflected on different aspects of safety culture based on the classroom discussion. Re-iterating a point stated earlier, the discussion raised a variety of issues such as values, behaviours and attitudes, responsibilities and so on. Although it is difficult to say whether the above participants were attuned throughout the course of the discussion, it is certain that they picked up and reflected on aspects they found worth reviewing.

Their reflections highlighted one or more issues they considered salient and which they chose to develop their unique perspective around. These participants were using their funds of knowledge to guide their reasoning and to communicate their point of view to their respective group members.

For example, participants like Milo, Izzi, Keira, Yul, and Theo found it useful to revisit vacation workplace experiences. Rex recounted an anecdote he had picked up at the IChemE safety course he had just attended, while Dax relied on a thought-provoking article from an IChemE periodical.

From a systemic thinking perspective, the above nine were being critically reflexive about the issue they had chosen to examine. The discussion had revealed to the above nine students that safety culture is a complex concept that involves safety related practices and responsibilities, attitudes and behaviours, values and priorities, mindsets, awareness and mindfulness and so on.

Upon encountering such a multitude of perspectives through which safety culture is conceptualised, it appeared that these participants were compelled to develop a relational framework in which these separate issues could be coherently linked. In the course of their reflection, while trying to develop a personally meaningful framework

these participants in turn synthesised new perspectives that contributed to the pool of ideas by which safety culture could be understood holistically.

For example, Milo's response enabled him to conclude that maintenance, improvement or change of a culture of safety is a collective and participative venture which presupposes safety to be a major priority.

For Rex, his reflection led him to recognise that the maintenance of a culture of safety necessitates that a deeper and heightened sense of personal, social and ethical responsibility is continually nurtured and strengthened.

Izzi and Keira strongly felt that ongoing safety education and training were vital to instil awareness, recognition and ownership of safety responsibilities. Both the participants realised that if safety is to be embedded into every aspect of a company then it must feature as part of the routine thinking process rather than an after-thought. Izzi and Keira came to recognise that good leadership is vital for changing mindsets toward safety.

In taking up the issue of perceptions, values, and priorities, Paloma, Shireen, Dax, Yul, and Theo, argued that differences in mindsets toward safety generate differences in commitment toward safety as well as workplace conduct. All of them exhibited awareness that for the maintenance, improvement or change in the culture of safety, a commitment toward safety is paramount.

They realised that although it is expected that the commitment must be exhibited at all company levels, it is, however, absolutely essential that it be demonstrated at the managerial level before it can be expected to be exhibited at the level of the frontline employees. While Paloma, Shireen, and Dax stressed this point, it is in Yul and Theo's perspectives that one finds just how influential managerial commitment toward safety truly is on workplace conduct.

In their own unique way, these participants arrived at an understanding that it is only company management which has the power to make available whatever resources are necessary to ensure that a workplace is safe and it is only authority which can establish and effect safe practices. Their understanding is in agreement with literature on safety culture. According to Hopkins (2003), it is indeed generally accepted that the responsibility for a culture of safety rests squarely on management, for it is the leaders who determine how a company functions and it is their decision-making which

determines whether an organisation exhibits the practices which go to make up a culture of safety.

In chapter 3, it was pointed out that from a risk management perspective, the systemic commitment to recognise and acknowledge the existence of multiple perspectives and to consciously strive to bring them into the foreground eventuates in a more rounded and systemic understanding.

The responses by Milo, Rex, Izzi, Keira, Paloma, Shireen, Dax, Yul, and Theo, strongly suggest that in their own unique ways these participants were successful in demonstrating that safety culture means different things to different people and this is largely because of differences in beliefs, experiences, feelings, attitudes and values.

Furthermore, they realised how such differences make the task of maintaining, improving or changing safety culture challenging. By engaging as they did in this activity, which necessitated putting the second commitment into practice, these nine participants were developing their ability to think systemically about ill-structured nature of safety culture.

6 Evidence of Epistemic Development: Experiencing Worldview Self-Transformations

In the preceding chapter, I addressed my inquiry's third guiding question: How can an educator ascertain that students are engaging in systems thinking in the study of PRM situations?

I provided a description of a set of workshop activity sessions I facilitated to provide students opportunities to practice their ability to think systemically. These activities involved using discussions and reflective blogs centred on the topic of risk, safety, and safety culture. Subsequently I presented narrative exemplars of student responses to some of those activities. Thereupon, I argued that these narrative exemplars ought to be construed as evidence of their engagement in systemic thinking in those activities.

In the present chapter, I readdress my inquiry's third guiding question: How can an educator ascertain that students are engaging in systems thinking in the study of PRM situations? In chapter 5 the evidence presented therein was characteristically performative in the sense that it demonstrated how students exercised the two methodological commitments of systemic thinking. But that kind of evidence is insufficient to infer that students were becoming competent at thinking systemically.

Evidence of another kind is also necessary in order to demonstrate that students not only practiced systemic thinking in those activities, but, more importantly that they truly understood what it is and why it is important in the context of PRM as a result of those activities. Therefore, this additional corpus of evidence must demonstrate that those activities had a transformative potential. It must demonstrate that the activities fostered students' epistemic development.

In the present chapter, I offer evidence to suggest that students found the activities described in the preceding chapter were transformative fostered students' epistemic development.

I begin by making a case for why a corpus of evidence concerning epistemic development is vital for the development of systemic thinking. I highlight some identifying features of this corpus of evidence. I identify the methods by which this corpus of evidence was gathered and highlight decisions pertaining to its analysis and

presentation. This section complements the methodological descriptions found in Chapter 2.

Thereupon, I present the corpus of evidence in the form of narratives. These narratives demonstrate that the interactions resulting from workshop activities attuned participants to not just the issues in focus but vitally also to the processes by which those issues were explored. The workshop participants realised that the dialogic and dialectical character of their interaction is vital to the development of systemic understanding of ill-structured process risk management related situations and the practice of systemic thinking. The narratives also show that the participants recognised the workshop activities were personally transformative to their understanding of risk, safety, safety culture, and systemic thinking.

Lastly, I argue that this corpus of evidence suggests that the workshop activities influenced the epistemological development of the student participants because their personal experiences of the activities are consistent with those accepted as transformative and epistemological developmental moments in the educational literature.

6.1 Rationale for the Focus on Epistemic Development and Worldview Transformation

How do we know that students are developing their ability to think systemically? The question merits due consideration as it is the basis for any sound and meaningful attempt to evaluate this competence.

An educator interested in understanding whether his or her formal attempt at competence development is successful, and whether the approach is worthwhile, must understand that evaluation itself is an inherently challenging activity. It is a complex undertaking and must be conducted mindfully (Baron, 1987; Nickerson, Perkins, & Smith, 1985).

Evaluation of competence is particularly difficult owing to complex constraints that unavoidably influence competence development. Firstly, competence development is not a production process that can be planned, directed by force or imposed, rather it is a deeply personal and social endeavour that requires not only ample room for active and intentional engagement, participation and reflection on the part of those who are to

develop their competences, but also requires that they draw upon personal reserves to persevere through possible learning defences and mental resistances or inhibitors emerging within the immediate learning environment (Illeris, 2009a).

Secondly, competence development is unpredictable, non-linear, and indeterminate because competences are perceived to develop only gradually through accumulated experiences of deliberate practice, such that no single experience can lead to the development of competence, yet each experience is likely to contribute towards its overall development (Bawden, 2007; Jarvis, 2009; Litzinger, et al., 2011).

Thirdly, competence development is uncertain in that although it is known that a favourable learning environment *is likely to* lead to development of competence, it is not certain that such an environment *will* lead to competence development (Knight, 2007). It is not possible to directly develop another person's competence, it is just possible to set the scene, to provide the tools and act like a catalyst (Sundberg, 2001).

In other words, a favourable and conducive environment is an essential constituent yet insufficient guarantor for competence development. Success requires learners to engage actively and intentionally in developing their own competences through the formal experiences afforded to the learners, while the requirement on the educators is that they provide a conducive space that encourages practice, interaction and reflection to foster the formation of competences. It is the educators' responsibility to attend to pedagogic encounters that make for good learning, and to orchestrate these encounters in relation to each other, the content, the available learning time and other resources (Knight, 2001; Knight & Trowler, 2000).

Fourthly, competences develop in a complex, socially situated learning environment through intricate learning processes with a wide range of varied influences at play, and this correspondingly introduces difficulties in comprehensively and accurately measuring learning outcomes or the effects of teaching (Walther, et al., 2011).

The above points, together, serve as significant caveats to assessment and evaluation in educational competence development. Contemporary competence development practices demand that assessment and evaluations are conducted in accordance with the epistemological premises of the theories and principles of learning that have been espoused (Boud & Falchikov, 2007; Bransford et al., 2006; Dysthe, 2008; Pellegrino & Goldman, 2008; Price, Carroll, O'Donovan, & Rust, 2011).

If one claims, as has been done in the pedagogic approach presented in this thesis, to have adopted complex, situative learning epistemologies for competence development, then no attempt ought to be made to measure complex learning achievements in terms of behaviouristic and cognitive learning outcomes (Haggis, 2011; Knight, 2007; Walther, et al., 2011).

A competence, as it is contemporaneously understood, is holistic in nature and possesses a significant tacit dimension, thus making it extremely difficult to teach as well as evaluate it. Authentic assessment of competences is impossible or at best exorbitant, time consuming and ultimately futile given that essentially tacit aspects of competences and the implicit learning processes involved in their practice are beyond capture, and what may be captured is only that which is readily measurable and only succeeds in trivialising and undermining the development of 'holistic' competences by reducing such competences merely to the transfer and acquisition of knowledge and skills (Dall'alba & Barnacle, 2007; Dall'Alba & Sandberg, 1996; Knight, 2004).

Experts recommend, instead, that assessment and evaluation of competence be construed as a holistic process (Beckett, 2009; Hager & Butler, 1996). This involves assembling selected samples of evidence of the performative skills and attitudes from which competence can be inferred with respect to the immediate context in which the said competence is enacted (Beckett, 2009). The exemplars of student participant responses in the previous chapter, Chapter 5, serve as evidence of the above kind in that they are performances of thought emerging out of the activities and processes of interaction that constitute the learning events (Greeno, et al., 1996; Hager & Butler, 1996; Haggis, 2006; W. S. Moore, 2002; Wolf, Bixby, Glenn, & Gardner, 1991).

But evidence of performances of thought, on its own, is insufficient. Systemic thinking, like other complex competences, develops over prolonged time periods, and develops only when one is genuinely committed and engaged in its development. Its development is complexly related to the uncertainty and unpredictability of the learning process, the influence of the learning environment, and the impact of each learner's motivation, emotional engagement, perceived practical value and relevance of systemic thinking and its subsequent effect on interest and attitude toward its development. Evaluation of its development, bearing in mind the above indeterminate, contingent and contextual nature of its learning and development, demands that one attend to what is perceived to be and pursued as the most worthwhile outcome (Knight, 2001).

What matters most for the development of systemic thinking is worldview transformation (Bawden, 2010; Churchman, 1968; Flood, 1999). Worldviews, in fact, play a particularly crucial role in the practice of systemic thinking. Systemic thinking, if we recall (See Chapter 4), is a useful means for the resolution of complex, ill-structured situations. One of the reasons why a particular situation is considered ill-structured is that it can be conceptualised in multiple ways, with multiple potentially valid solutions (Kitchener, 1983). These multiple conceptualisations are attributed to the differences in the worldviews of the various participants involved in the resolution process, and those differences, in turn, are attributed to the participants' personal, social, cultural, and professional backgrounds, and differing perceptual acuities toward the constraints and affordances of the situation.

It is because of differences in worldviews that various participants claim different sets of facts. Worldviews powerfully influence and direct the unique ways in which people attend, value and make-sense in relation to the particularities, opportunities and problematic aspects of the situation they are in (Clancey, 1997; Schön, 1987). Consequently, effective systemic thinking is impossible without appropriate resolution and management of worldviews. In resolution scenarios that demand systemic action, agreement upon a particular line of action is understood to arise when worldviews are shared or reconciled amicably; whereas conflict is understood to result from tension between divergent worldviews.

In addition to the emphasis on acknowledging worldviews, it is equally important to realise and acknowledge a systemic view of the world. Before one can think and act systemically one must come to believe in the systems worldview. Systemic thinking is a way of dealing with real world complexity founded upon a very specific way of knowing and understanding (See Chapter 3). It assumes that this perceived complexity can be examined and dealt with accordingly only if we accept that such complexity arises out of the interplay of numerous relationships between various entities through multiple events, interactions and their emergent consequences.

Systemic thinking demands the recognition and acknowledgement of systemicity, in that it is primarily a way of seeing, knowing, being, and acting in a world where entities and events are intricately interconnected and impossibly inseparable, and knowing (making knowledge) and acting (taking action) are strongly contextual phenomena. The

recognition and acknowledgement of systemicity is however, as Bawden (2010) tells us, no easy feat to accomplish:

> *The ability to adopt a systems (or systemic) perspective to some issue or another in the real world, and to use systemic practices to achieve changes to it, are not at all a straightforward matter, of simply learning systems theories or learning to use systems methods in practice…The transformation of complex situations in the world in a systemic manner will only effectively happen if those who need to act to achieve those transformations are themselves transformed in the way that they 'see' that world and 'act' in it. This self-transformation involves challenges and changes to those profound sets of beliefs and values that constitute the perspectives that we each use to make sense of the worlds about us. (Bawden, 2010, p. 91)*

According to Bawden, one can effectively practice systemic thinking only if one's worldview has been transformed to recognise and accept systemicity. Development of systemic thinking is impossible without it. The significance of this very point cannot be overstated enough because in the absence of a systemic worldview one would find it particularly challenging to consistently situate complex problems with respect to a wider context. It would be impossible to arrive at a systemic resolution if one did not possess an acute appreciation of the features of wholeness, interconnectedness and emergence that characterise such situations.

The point of significance to be drawn here is that, in order to evaluate whether one is developing the ability to think systemically, it is imperative to look for evidence of worldview transformations. However, the caveat to be borne in mind here is that although worldview transformations do indeed occur, they do not occur overnight. Worldviews are not transformed by force or imposition (Capra, 1997; DeWitt, 2010; Henry, 2012; Hilgevoord, 1994).

Dominant worldviews are abandoned only in the face of glaring absurdities, with a new one adopted when the older is found no longer viable (Davies & Gribbin, 1992; DeWitt, 2010; T. S. Kuhn, 2012). Also, it is impossible for one person to transform another person's worldview, but it is possible for each person to transform his or her own worldview. Such transformations are likely to happen when individuals encounter situations which challenge their cherished worldviews and the beliefs, attitudes and

assumptions and provoke the examination of the viability of beliefs, attitudes, and assumptions (Bawden, 2010; Mezirow, 2000).

What ought to be sought instead, from an evaluative standpoint, is evidence of self-transformation in the course of epistemic development (Bawden, 2005, 2010; Bawden, McKenzie, & Packham, 2007). We are to look for those instances where changes to particular beliefs are "triggered by the arguments of others as well as by the sheer weight of previously ignored or newly generated evidence" (Bawden, 2010, p. 96); instances which "shake a student loose from 'provincial' commitments to limiting worldviews" (Salner, 1986, p. 232); instances when upon encountering a discursive situation perceived as anomalous or as one that presents a disorienting dilemma, a student is compelled to become critically reflective.

The person proceeds to examine his or her own worldviews and seeks meaningful reasons to arrive at an informed and contextually appropriate judgment regarding those worldviews. As a result, he or she constructs a clearer understanding of that situation and any potential actions that are to be undertaken. This understanding is transformative, it makes the person more inclusive, discerning, open, reflective and emotionally receptive to change (Mezirow, 2009).

6.2 Decisions Concerning Evidence Gathering, Interpretation and Presentation

The evidence featured here manifested from four group interviews with workshop participants who were keen to participate in my research inquiry. Interviews were the preferred method for gathering relevant evidence since they directly enable the interviewer and interviewees to express and exchange personal worldviews on topical matters (Cohen, Manion, & Morrison, 2007a).

The interviews were semi-structured so as to draw on the strengths of both the informal conversational approach as well as the guided interview approach. They were guided in the sense that there were a set of issues and concerns I wanted to discuss with my interviewees (See Appendix 11). However, the actual sequence in which these issues and concerns were raised and the manner in which they were asked varied in relation to the situation and the evolving dynamics of the interacting participants.

Also, the interviews were conversational in that the questions asked were open-ended so that interviewees "can answer the questions in their own way and in their own words" (Cohen, et al., 2007a, p. 354) and questions spontaneously emerging in the course of the conversation were also pursued by means of relevant and timely prompts and probes.

Group interviews were deemed appropriate owing to their multiple affordances. As Kamberelis & Dimitriadis (2005) highlight, firstly, they generate voluminous responses from numerous interviewees in a short span of time; secondly, responses are emergent in that the dynamic and interactive character of these interviews facilitates a synergy between interviewees which can lead to significant insights; thirdly, such an interview space is conducive to genuine understanding of topical issues and concerns since it foregrounds multiple perspectives and provides access to individual and collective funds of knowledge, memories, opinions and practices.

These group interviews were conducted at the end of the semester ensuring that they did not clash with the participants' end-of-semester examination schedules. I invited 43 participants for these group interviews. However, owing to various other commitments or scheduling conflicts, a significant number of my workshop participants were unavailable. A total of 19 students attended these group interviews, with 6 interviewees in the first group, 7 in the second, 1 in the third, and 5 in the fourth and final group. The third group interview naturally evolved into a lengthy open-ended conversation since all the scheduled attendees bar one either dropped out last minute or rescheduled their attendance to the second or fourth group interviews. All the group interviews were recorded using a digital audio recorder, and were thereupon selectively transcribed (See Appendix 12– Appendix 15).

Like those in the preceding chapter, these responses too have been interpreted, organised and presented in a narrative form. This is in part, owing to the recognition that interviews produce "narratives of experience" (Fontana & Frey, 2005, p. 698), and in part because narratives are the primary source from which to access, build and update worldviews (Herman, 2003b).

To complement these responses where necessary, excerpts from selected student participant reflective blog submissions have been utilised (See Appendix 16– Appendix 20). The documents were designed to serve as significant sources of evidence of epistemic development and worldview transformations in addition to their primary role

of being formative assessment instruments. This step became vital in order to accommodate the views of those student participants who could not attend the group interviews on any of the scheduled dates but were still keen to participate in the research inquiry.

Relatively short quotations such as specific words and phrases extracted from either the group interviews or reflective blogs are enclosed within double quotation marks (""). Longer excerpts, chiefly arising from the reflective blog submissions, are introduced explicitly whenever appropriate and then presented at length following a colon (:). The quotes emerging from group interviews are presented verbatim.

In order to maintain the authenticity of natural speech arising in an interview setting, additional punctuation marks have been used in combination. For example, a momentary pause is indicated by a period parenthesised within round brackets ((.)). A comma (,) indicates a slightly longer pause. Instances where the speaker rapidly introduces a train of thoughts or ideas in quick succession are indicated by three periods (…).

Whenever, either in conversation or in writing, a participant refers to a particular company where he or she completed crucial vacation work experience or worked as a part-time employee, I have avoided furnishing the name of the company. However, to maintain the contextual integrity of that piece of narrative, I have described the nature of work undertaken or service provided by the said company.

Although nineteen student participants attended the group interviews, it was impossible to conclusively construct a coherent narrative to demonstrate how the workshop activities and processes encouraged each participant's epistemological development, and when and if, in the course of their engagement, each participant undertook a self-transformation of worldviews. I did, however, succeed in constructing five coherent student participant narratives to demonstrate that they satisfied the aforementioned twin objectives.

It is important to recall, yet again, that the situative and constructive dimensions of every social situation significantly influence the actions of all human participants involved in it. Each participant is likely to make sense of the situation in a unique way, and to selectively attend to and engage in it in a personally meaningful way. The evidence gathered from the group interviews and other supporting documents are

similarly constrained by the above dimensions. This is particularly evident in the variations in the student participants' descriptions and definitions of systemic thinking. But this is to be expected and welcomed. Not only because of the situative and constructive dimensions underpinning their understanding of systemic thinking, but also because systemic thinking is conceptually hard to precisely describe and define. As Flood (1999, p. 82) puts it bluntly, "is not something that can be explained easily and understood comprehensively."

The forthcoming narratives, therefore, are simply indicative of that fact that, having experienced it through practice, and then thinking and talking about it as they do to the best of their ability, these student participants are demonstrating an "intuitive grasp" of systemic thinking (Flood, 1999, p. 83). The narratives have, instead, a more important purpose to fulfil. As stated in the chapter introduction, my intention is to narratively demonstrate that the workshop activities influenced the epistemological development of the student participants and provided encounters to invoke a self-transformation in their personal worldviews over the course of those workshop sessions.

This demonstration will be executed in the following pages using a two-tiered interpretive format. At the first level, five narrative cases will be presented to show that (a) participants attuned to not just the issues in focus during the workshop activities but vitally also to the processes by which those issues were explored, and (b) that the participants experienced personal transformations in the course of their engagement with those activities. Section 6.3 below and Section 6.4 below operate at the first interpretive level. Thereupon, at the next level, the cases are summarily reviewed to demonstrate that the unique responses and experiences of those five student participants, when taken together, strongly suggest that the student participants experienced epistemic development and a transformation toward a systemic worldview as anticipated through the workshop activities and processes. Section 6.4 operates at the second interpretive level.

6.3   Experiencing Systemic Thinking: Discussions Seen Through the Eyes of Chuck, Leah, and Samara

When I facilitated the workshop activities, I anticipated that in the course of engagement, workshop participants would become aware of the fact that dialogue was

a vital epistemic process for systemic thinking. I was both delighted and relieved when participants acknowledged this in their observations.

Chuck, Leah, and Samara are three workshop participants who most explicitly noted this relationship. Each of them was in a different group and attended either the Monday or Tuesday session. For example, Samara attended the Monday workshop sessions, whilst Chuck and Leah attended the Tuesday workshop sessions.

As the evidence below will reveal, in this instance, Chuck, Leah, and Samara, have a unique perspective on what happened in their respective group during the third workshop session and how this relates to systemic thinking.

Chuck realises the systemic nature of corporate safety culture

In the group interview when I asked the participants about their thoughts on the workshops and whether they could note a connection with systemic thinking, Chuck responded in the affirmative. To him, the workshop activities "gave another sort of platform and area to discuss and to learn more about the things we were already learning about but in a more…in a less focused way, in a less specific way, and more like…let's deal with larger ideas and broader." He was referring to safety culture, what he experienced prior to enrolling in PRM, and what he experienced during the workshop activities.

He had earned invaluable vacation work experience as an engineering subcontractor on a large-scale service project for an international energy engineering company. The experience made him aware of the importance of a serious and concerted commitment to safety. "Vacation work exposed me to a lot of things I didn't realise," Chuck said. "I didn't realise how pervasive it was throughout the company, and intercompany relations, and down to the employee level and how much everyone talked about it, how it was reinforced….safety first, safety first…and like the environment. Because obviously modern Australian companies you get a lot of…the safety culture," he continued.

The workshops gave him the opportunity to think more mindfully about his experience of safety culture. "While in the workforce it's like they tell you, but you're there to work for them. They assume you know it, it's a part of the company culture; it's not really talked about that much," Chuck noted. "I feel I went into it a bit blind really," he said as he recalled his experience. The contracting company that hired Chuck had a strong culture of safe engineering practice. "They had their program Target Zero…zero harm to

people, environment, and community. And you think like, aww yeah that's cool, they have to have that. But you don't realise that sort of," he observed.

It was in the workshops, however, that the concept of safety culture became clearer to him particularly as it was practiced by the company that hired him. "I guess the workshops helped discuss why they have it, the selfish and unselfish reasons…and that they want to protect their reputation, have a good reputation, but also because they have to protect the environment and that," he stated. As he put it, the workshop activities brought greater resolution to his understanding of safety culture, "otherwise it would be an airy-fairy thing; you don't know what it means, where it fits."

The third workshop session, it appears, was particularly eye opening. He recounts it in his reflective blog as follows:

> *During the third workshop, it became increasingly apparent to me the diverse and sometimes mind boggling experiences others have had regarding their individual work experience regarding safety culture and Health, Safety, and Environment (HSE) in general. Our group consisted mostly of international students who had completed various casual and engineering work experiences in Australia and back home. Their experiences in Malaysia and Indonesia (countries with far larger populations and generally poorer people) included small companies who completely neglected safety to larger companies who would readily neglect their safety culture in order to save money. In richer countries, companies would not sacrifice corporate safety culture even during downturns because any slip up could prove fatal to the future of the company. These cultural differences were astonishing - people are not valued as much as they are in developed countries like Australia. I am glad that I sat with this group of people because subsequently it allowed me to reflect on my own experiences and to critically review what safety culture meant to me.*

His experience was in stark contrast to those his fellow group members narrated. It led him to revisit what he now perceived as a "pervasive and highly ingrained corporate safety culture." "From high level work to low level work; discussions with colleagues, meetings and so on, safety was always a priority and was never forgotten," Chuck emphasises.

The Target Zero safety program which the entire company administered and adhered to now appeared to him as being "systemic" in outlook. ""Target Zero – Zero Harm to our People, the Environment, and the Communities in which we operate", this is a systemic approach to having a proper safety program because it recognises the influences and effects an engineering company has outside itself," he realises.

He goes on to narrate some memorable critical incidents which highlight the resolute commitment demonstrated in practice, both by the engineering company that hired him as well as the large energy services company to which he was contracted. His work involved brownfields operations on Barrow Island in Western Australia, which is a Class A Nature Reserve.

The client energy services company has an oil and gas operations project on Barrow Island, and is reputed to maintain "incredibly high standards for safety and operations." All the work he did, Chuck insists, "had to fall inside the correct procedures." It had to comply with Western Australia's environmental policies, as well as the client company's tenets of operational excellence and safety. He had to imbibe and enact the motto "Think Incident Free (TIF)." He recalls the opportunity to undertake a day-long site visit to Barrow Island:

> *I was flown onsite to Barrow Island for a day - this involved strict procedures as described to me in a comprehensive HSE induction…Every single person going onsite had to complete and pass the same induction - engineers, operators, cleaners, chefs and so on. My pockets and boots had to be free of dirt before boarding the plane, all cars on the island use a special key which connects to a satellite system that monitors location and speed all the time and reports back on how good the driver has been, and no non-intrinsically safe tools or instruments (like cameras) could be used within 15m of any operating facility or equipment on the island - only a few significant examples of the safety culture I was a part of…As Barrow Island is a Class A Nature Reserve, the care taken for environmental impact is always a high priority. There is a desire in all engineering work to not only comply with standards but give a reasonably, slightly over-conservative consideration in order to go above and beyond the environmental precautions already in place. All of us knew that it was a delicate system…thus we felt ethically*

obliged to follow correct procedures and responsible for the safety of people
and the environment on the island.

As a result of the discussion, listening to the experiences of others, and contemplating upon his own experience of safety culture, Chuck recognised the benefit of thinking systemically, particularly in relation to risk and safety. As he put it, "systemic thinking is key to thinking safer and more ethically, as it encourages you to consider more perspectives than just your own, and provides a more rigorous method for fleshing out safety issues and more specifically, ethical issues which occur as a result of a breach of safe practice."

His recognition, it seems, followed from a transformation in the way he viewed and thought about corporate safety culture. He recounted a sequence of events that had occurred toward the end of his stint at the engineering contracting company. The CEO of the company sent out a company memo regarding HSE updates and concerns. It informed the employees that there had been an accident with a truck and its access on a slippery slope in Papua New Guinea. A worker had fallen and had been badly injured. The CEO explicitly indicated to the employees that as an immediate response to this accident, better access ladders would be added to the back of all trucks in order to avoid recurrence of such an accident.

Chuck, now looking at that sequence of events in hindsight, realised why the CEO issued such a specific directive. It was not obvious to Chuck at the time, but now he was able to put himself in the CEO's shoes and consider his perspective. Defending the CEO's decision, he remarks, "His reaction was systemic – he knew that the worker would not be able to provide for his family during the time spent in hospital, and it reflected badly on the foreign engineers from the company working in a foreign environment as it could be seen that the employer can't look after its employees."

As Chuck saw it clearly now, this decision was justified and was strongly aligned with the contracting company's safety goal of actively reducing the number of accidents per million man-hours. According to the CEO this goal was being actively pursued, and the numbers were decreasing. Speaking on behalf of the CEO, Chuck observes, it was "a trend he wanted to continue in order to justify the stringent safety culture in place."

To Chuck, the third workshop session transformed his understanding of safety culture, as he notes in the conclusion of his final reflective blog:

My discussions with the group the third workshop allowed me to see safety culture from a wider perspective through the lens of what I already knew – it is only positive and always lends the organisation a good reputation through good times and bad. However, pervasive does not mean easy - it can be tiresome as an employee to go through all the motions every single time, and this tediousness is heightened when it seems pointless. That is why a systemic attitude towards it must be maintained always; ensuring each individual employee knows they are doing it for their colleagues, families, wider community, environment, society in general and not just themselves.

His personal experience of safety culture was one which was "pervasive". But he realised, having conversed with fellow group members and in acknowledging their perspectives, that such a culture of safety can only ever become so pervasive when a systemic outlook is accepted, appreciated, and "maintained always." Chuck now came to understand safety culture as an interconnected web.

Leah realises that systemic thinking is best undertaken as a group enterprise

I wanted to know if my group interview participants felt that systemic thinking is more effective when undertaken with a group of people or was it more productive as a solo venture. The group interview participants were unanimous in their support of the power and benefit of systemic thinking as a group undertaking.

Leah, in particular, felt that group dynamics was crucial to systemic thinking. "Everyone has different ideas. And since you are supposed to see interconnections between things, it's always better to have more than one person," she said. Her experience at the third workshop had convinced her of it.

She wrote her reflective blog specifically to demonstrate how systemic thinking is efficacious when the power of a group is harnessed. In her blog she recounts her understanding of the task to be accomplished:

The issue that was explored in the third workshop had each of us assume a role in the management team of a chemical plant which plans to take pre-emptive action to maintain the confidence of our investors following extensive news coverage of explosions that had recently occurred at another chemical plant. The action to be taken was the exploration of what makes a

good safety culture as a means of providing safety assurance to our investors.

This exploration, she contends, "was carried out in a systemic way." Having attended all the workshops and through "independent reading" on her own time, Leah had developed a working definition for the process of thinking systemically. It was a conceptual process, one that "involves relating concepts together from a parent concept and also exploring the interactions between the smaller concepts and their individual and/or combined effects on the system and surrounding." It also involves "critical reflection" wherein, according to Leah, to examine an issue one ought to "compare and contrast various viewpoints."

Leah had borne her working definition in mind as she approached the task undertaken in the third workshop session in order to complete it with the help of her fellow workshop participants. She highlights three methodological steps by which their discussion proceeded:

We were able to successfully apply a systemic approach to the analysis of the notion of safety culture in a group discussion where: opposing viewpoints were raised and interconnections were and drawn between the issues and concepts that were identified; five main concepts under which most of the issues we had discussed could be placed were proposed; common inclusions and omissions to our group discussions were identified.

Leah then furnishes various instances from that discussion to illustrate the outcome of each step above. For example, to show how these steps were instructive, she recalls an instance from the discussion when the issue of safe workplace behaviour was raised. The group considered whether safe workplace behaviour was to be understood from the viewpoint of a responsibility or that of an obligation. She remembers:

We were able to identify that the former would lead to consistent safe practices while the latter would be more likely to encourage employees to cut corners and cover up their mistakes. The opposite situation could also exist, where an employee chooses to take an unsafe action or they are forced by their superiors or peers to practice unsafe behaviour. Both of these situations can be seen as going against the general consensus but in directions. The former is taking risky behaviour in an environment where

such actions are not promoted or encouraged and the latter is resisting the unsafe practices in an environment where such behaviour is the norm or even enforced through coercion.

This instance of deliberation helped the group understand that a subtle difference in how an issue is viewed and enacted can significantly influence the consequences of practices pursued when one viewpoint is preferred over the other. Through further deliberation on multiple viewpoints and issues, the participants reasoned that "commitment, transparency, reporting, review and enforcement" were "key elements of safety culture". The discussion enables Leah to realise that the above elements "could also be considered parent topics for the issues that had arisen from our discussion."

Leah felt that having an inter-group discussion during the workshop was particularly beneficial. Her observation about group formation and dynamics was that when people form groups on their own, group members tend to be "people on the same wavelength." Discussions, then, are particularly constrained. They are "not as useful" because the members of such a group tend to "have the same ideas." But inter-group discussions overcome that limitation because "new points are added, and the discussion grows." This became particularly obvious to her in the workshop. "In hearing from each group their notion of safety culture, not only could we see recurring issues and create more extensive connections between the issues and concepts but we were also able to identify what was omitted from each of our discussions," Leah insists.

Samara realises that systemic thinking is effective when multiple and contradictory perspectives are included

Samara experienced a noticeable shift in her understanding about safety culture in the course of the third workshop session. She felt that the shift came about because she and other members of her group were able to successfully complete the activity through systemic discussions.

Her engagement in previous workshop sessions and similar problem formulation discussions undertaken in the weekly PRM classroom activities led her to understand systemic thinking as a holistic and discursive approach. "It is about identifying, understanding and appreciating differences and similarities in viewpoints between people to try and gain a more comprehensive understanding of a topic and being able to

recognise and hence approach issues considering other people's perspectives and the perspectives of other systems and/or the environment," Samara said.

As she saw it, the discussions were a means to think systemically about a topic or issue. Particularly in the third workshop, the objective was "utilising systemic thinking to conceptualise the notion of safety culture." Her team had twelve members. The members had a quick preliminary discussion to decide a way forward:

> *The team had a brief discussion and threw around some ideas to work out how best to approach the task, we quickly came to the decision that we should appoint job positions that were likely to be present in a real-life situation and then go around the table introduce ourselves, introduce our job and what we think it would entail, discuss our own personal viewpoint on safety culture and how we personally would approach the task based on our own values then discuss how we as our job position would be likely to approach the task.*

Following this preliminary discussion, having chosen their job positions, the members proceeded to exchange their respective viewpoints as proposed. Samara recalls at length:

> *My personal job description was the public relations manager so with this job description in mind and my own personal stereotypes and attitudes towards how a person with this job description would view safety culture and the things they would tell the stakeholders about the safety culture within our company I, and the rest of the group were able to effectively employ systemic thinking to the concept of safety culture. The group had an effective discussion on what safety culture means to both ourselves and the person we were acting as and came up with a whole host of ways in which we could ensure that a good safety culture was in place within our company so that we could convey these concepts to the stakeholders in question.*

In hindsight, Samara perceives the proposed discursive approach as particularly insightful. "I found this approach to be very useful because it really forced you to consider how your viewpoint can be altered by things such as your experiences or your job description and it pushed you to consider the perspectives of a person who may have a completely different notion of safety culture than yourself," she declares.

Samara had such an experience during the discussion. She thought it was interesting that many of her team members were strongly inclined to support negative consequences like instant dismissals to enforce safety culture when someone did not comply with established safety practices of a company.

Her view on the matter was contradictory to those of her team members. It was informed by her part-time and vacation work experiences in companies where safety culture was encouraged through reward and recognition systems. In one company there are cash rewards in the form of gift vouchers for the employee selected as the safety team member for each calendar month. This award is conferred upon that employee by a company-wide voting process which recognises and appreciates behaviours that comply with the occupational health and safety policies enacted by the company.

In the other company too there are cash rewards for completing thoughtful and insightful assessments of personal safety in the workplace. The prevailing safety culture in that company is one where you are encouraged to identify unsafe as well as safe behaviours and to have discussions with the person enacting unsafe behaviours so that he or she can develop an understanding of how other employees view their behaviours and how to better align his or her conduct in alignment with the established safety culture practices of that company.

Samara's discussion led her to understand that the viewpoints of her team members were as valid as her own, and that the validity of these contradictory viewpoints was subject to context. "After listening to those with the alternate viewpoints it became clear that negative consequences were more typically employed in the very high risk situations such as on oil rigs where noncompliance with the safety practices and culture is more likely to result in drastic consequences and the concept of penalties for noncompliance became easier to understand for me," she admits.

6.4 Experiencing Systemic Thinking: Reflective Blogs as Seen Through the Eyes of Pia and Viggo

I anticipated that in writing their own reflective blogs, providing their peers access to their blogs, and commenting on each other's blogs, workshop participants would encounter one another's assumptions, beliefs and value positions and would exercise reasoned judgement when faced with viewpoints that are congruent or contradictory to their own.

The reflective blogging exercises were purposive in that they were a deliberate pedagogic means to attune workshop participants to the existence of multiple perspectives and to take a critical reflective stance towards those perspectives. As the evidence below will show, Pia and Viggo became critically reflective in their own unique way.

Pia realises the need to be open-minded in the face of multiple and contradictory perspectives

In the group interview when I sought participant views on the usefulness of the reflective blogs, Pia enthusiastically responded that she particularly enjoyed this activity. "I liked reading other people's blogs. I actually liked reading other people's blogs more than mine," she affirmed. Her experiences of reading and responding to the reflective blogs of her fellow group members like Shireen and Lennox had exposed her to the fact that people can and do think differently. "You see the blogs and see how they thought about it," she remarked.

This posed an interesting challenge when she chose to comment on the reflective blogs of fellow group mates. Pia was aware of the fact that comments are seen as judgements on the viewpoints of others. She could agree or disagree with those viewpoints. Agreement on a viewpoint did not inherently make it right or good, nor does disagreement necessarily indicate that the other person is wrong and his or her viewpoint is bad.

In such matters, as she points out, "there is no real black and white definition." As she understood it, matters of morality and ethics are grounded in human perception. "The point is that right and wrong, good and bad, are conceptualised completely through human thought, and again come back to how each individual person perceives their own world," Pia emphasises.

She recognised the peculiarity of how the above phenomenon can influence every person. It was obvious to her that "every person holds different morals based on their beliefs and values." "But I guess everyone's set of values differs just enough to mean that someone else, when put in the same situation as you, would behave and act completely differently," Pia adds.

She introspects on the ambiguity of social situations and actions. "Who are we to be the judge of what is real and what is not, or of what is undeniably right or wrong? As

humans we're completely bound by what we're physically capable of knowing and experiencing, and who are we to say that our own eyes don't provide us with a distorted lens through which we perceive our world?" Pia inquires.

Differences may genuinely be differences or they may be distortions in one's perceptions and thoughts. Pia felt the need to be wary of the existence of such distortions and to act appropriately. "Often until we have been shown or opened up to a different way of thinking or looking at a particular situation, we're likely to glorify and follow completely our own way of thinking based on what we have known up until that point in time," she observes.

Pia recognised commenting on reflective blogs as a social situation. She saw the need to comment in a respectful and ethical manner so that distortions of thoughts and perceptions could be exposed – her own as well as those of her fellow group members. She chose to be thoughtful in her exchanges with fellow group members. "If you were commenting constructively you had to try and firstly put yourself in their point of view so that you could comment on what they'd already said, which is difficult sometimes," Pia informs.

Pia began her comments by expressing solidarity with her group member, briefly reiterating the author's viewpoint that resonated with her. She proceeded to announce that there was one other viewpoint with which she disagreed and then declared it. The declaration was followed by her reasoning. She did, however, strive to appreciate the author's perspective and rationale, and then offer an alternative perspective which enabled the author to notice the distortion in the original viewpoint. (Refer to Appendix 6I for Shireen's reflective blog response in Week 6, Pia's comment on it, and Shireen's return response to Pia's comment in which she thanks Pia for her clarification and comments.)

To Pia, it is important to be respectful and considerate toward the way other people thought. She recognised the need to exercise empathy. "People don't care about what other people think. But I think this kind of made it obvious that it is actually beneficial to listen and care about what other people think," she asserts. Too often, we are conditioned to think in certain ways and believe our perspectives to be unimpeachable. Pia realises, however, that "everybody could in some way justify and argue" for their respective positions and viewpoints, "without being entirely wrong." "An open mind tends to come in handy," she emphasises.

Viggo realises that systemic thinking is characteristically different from systematic thinking

Viggo's interest in systemic thinking was largely sparked and stoked in the course of writing his third reflective blog responses. "Initially I didn't actually understand what systemic thinking is," he admits. "Only towards the end when we had to write the reflective journal on the systemic thinking, we had to relate. Then I had to actually go and research more about it and do more readings on systemic thinking then I understood what systemic thinking is," Viggo added.

When he wrote the previous blogs he wasn't sure whether he was being systemic in his approach. He thought he was, but it wasn't clear. "I did not understand what systemic thinking was so I was just thinking to write a blog that's all. Just doing it for the sake of doing it," Viggo reported. He felt that he wasn't thinking broadly in the second blog. "I noticed that the second one was still, my thinking was still narrow," Viggo mentioned. I asked him for an example to illustrate what he meant by narrow thinking. To this he responded:

> *Okay. In the second blog I was thinking of one system. I was looking at one problem, like the problem was that incident in England. I looked at one part of it individually and then I wrote about the individual parts around it. For the third one I actually looked at how systemic thinking, I looked at the overall thing, and related everything to one another. I actually defined systemic thinking in that blog.*

He perceived a change in approach. "As I went from second to third I noticed that I looked at it in a bigger, wider perspective," he stated. This change of approach, it seemed, was triggered by the task set up in the final reflective blog. "It asked us to write about how did you use systemic thinking to conceptualise safety culture," Viggo recalled. It prompted him to search the internet for information on systemic thinking, finding multiple competing definitions and comparing them in order to develop his understanding of systemic thinking.

He had initially thought that "systemic" was the same as "systematic." But his online endeavour proved particularly instructive in highlighting that they were indeed disparate terms. "That's when I really, really differentiated systematic and systemic," Viggo affirmed. To think systematically requires one to follow "a set procedure."

Systemic thinking, on the other hand, has a different emphasis. For Viggo, it is a combination of two modes of thinking. It is, in part "analytic" in that one identifies various "known elements" that constitute a topic of interest, and in part "synthetic" in that one attempts to then "relate" and interconnect those elements "to one another."

He felt he is largely the former kind of thinker, and not as proficient at the latter. "It's not something, personally, it's not something that I'm good at because I'm more of a systematic thinker...I usually follow strict guidelines," Viggo observed. However, through the learning activities in PRM over the semester, he came to appreciate the difference between systematic thinking and systemic thinking. "I noticed like systematic can be almost robotic; the way you think of stuff that you don't consider other factors," he declared. "But I see that systemic thinking is a very useful approach to thinking of problems or matters because it helps you be a bit more flexible in your thinking methods," Viggo added.

Systemic thinking demanded that his attention be directed differently. When concerned with any topic or issue, "you need to sit down and then reflect on it and look at the bigger picture," Viggo asserted. It required a conscious, deliberate effort to attune to this way of thinking. "I think you're more focused on what you're, the way you're thinking. As in, am I? You question yourself is this the right way of thinking, if I am using systemic thinking? And is this the right approach to think of the particular topic?" he reported. This increased attention on how he is thinking about the topic at hand not only compelled him to consider the topic to a greater extent but it also generated greater resolution regarding the topic in focus. "After thinking you'd see the result of it. You have a better view of the result you get," Viggo said.

The increased attention on the thought process had a payoff for him in understanding PRM. "Before this unit I didn't know that you have to consider all those external factors for [process] risk management. But in doing this unit I noticed that even legal terms play a part in [process] risk management. Or something unrelated can be related," Viggo commented. "And there's no set procedure into [process] risk management. There are different approaches for it. I learned that there are so many procedures in tackling risk management problems. But I understood that we needed systemic thinking to approach these problems," he quickly added.

Not only did he believe systemic thinking to be useful for approaching PRM problems, he also felt that it ought to be customary to an engineer's problem resolution sensibility.

"In engineering, systemic thinking is a generic thing for engineers," Viggo remarked, "because they need to consider so many things. They can't think in only one way, because if they approach things at one way you won't find problems to your solution. In [engineering] (.) there is no best or ultimate solution. There's a few solutions that you can, engineers look for."

Systemic thinking, it seemed to him, enables one to better understand an engineering problem. He explained with an example using concepts from the discipline of oil and gas engineering which he had chosen to specialise in. "In terms of solving a problem you need systemic thinking…you need to look at the overall picture…[If] you need to say understand how to drill a well, you also need to understand the surrounding. Well reservoir porosity, reservoir permeability, the properties of the reservoir itself. So you need to know, understand those theory points so you can use systemic thinking. We need to consider them," Viggo illustrated. "Systemic thinking would give you a better understanding of the overall picture which…you can work with," he emphasised.

But systemic thinking is not without challenges. Viggo realised that in order to be effective at the systemic resolution of a problem scenario one must be mindful of certain interdependent aspects of this process. Firstly, it is vital to recognise that a problem scenario is itself a systemic occurrence. "It would mean if you're thinking of a problem you have to look at every part around it and consider how the parts around it can affect it. And what it can do to other parts around it," he explained.

It is imperative to think relationally. The problem, as he put it, is "not a localised problem." It is a problem system and those involved in attempting to resolve it systemically need to understand that they are a part of that problem system too. Therein lay a critical constraint. "The limit to systemic thinking in my opinion is the amount of knowledge you have within the system, of the system," Viggo highlighted. "The less knowledgeable you are, the less factors that you know of," he asserted. It was a significant insight for him so he reiterated it with a positive spin. "I mean, if you know more about the system you get more information out of it. Hence get a better solution," he declared.

But there is more to that limitation as he saw it. To secure an overall perspective also means you need to "be open-minded." It is not possible to generate such a perspective alone. It is necessary to be inclusive and recognise that systemic problem resolution is a matter of shared understanding. Just as he, being a part of the problem system, would

look at it and develop his understanding of it by generating knowledge and information as he saw fit, so, too, would others. Each person involved is likely to see that problem system in a particular and personal way. "Everyone has an understanding for a certain kind of system…you need to consider all that," Viggo proposed.

The above point became evident to him in the course of his classroom discussions in PRM. The discussions frequently refined his understanding. "I found it really helpful because when I came to class and we had discussions I understood it a bit more…the effort that I put in was on my own understanding. It might be different to other's perspective. So when we came to discuss and we all thought about it, it defined the topic a bit more," Viggo revealed.

Discussions led him to realise the directive force of opinions in the problem resolution process. "If you have an analysis I would have a certain opinion about whether we should consider an aspect of the problem. But someone else might say, don't worry about it because that's not a major part of it," he noted. To Viggo, such differences in opinions assist in the recognition of the perceived boundaries of a problem.

Thus, following from his experience of discussions, to be open-minded is a necessary step to the exploration of the reciprocal relationship between opinions and problem boundaries. Inclusivity is critical for shared understanding because systemic resolution is unlikely without proper resolution of opinions on boundaries. "I noticed that opinion plays a big part…that's where the boundary comes in. You need to know where the boundary is," he emphasised.

Viggo considers systemic thinking as an explorative approach to understand a problem system. "Identifying more of the system and considering more of it rather than being very localised," he stated. But its efficacy is directly related to time. The more time one can afford to invest, the more effective one is likely to be at systemic thinking. "Because systemic thinking requires you to learn such a broad spectrum, I don't know if that's the right word for it, broad field…it really depends on the amount of time you're given to learn something and the depth that you wanted to look for," he clarified.

To think relationally, to attune to the overall perspective, and to be inclusive of various opinions in the interest of surfacing perceived boundaries of a problem system, also imply accepting the time intensive nature of systemic problem resolution. To him, this also meant that to in order to be effective at systemic thinking one must recognise when

to use it. "Now that I know what systemic [thinking] is, I know when to use it…if you look for bigger depth, more, more in-depth, you probably go with systemic thinking," he declared. Viggo then added that it is, however, important to accept the following caveat in practicing systemic thinking, "We wouldn't be…an expert on something. It would be a broad overview."

6.5   Experiencing Systems Thinking: Discussion and Conclusion

In the preceding section, I presented five narrative cases to illustrate how the twin processes of dialogue and reflective blog exercises were catalytic to Chuck, Leah, Samara, Pia, and Viggo's experience and understanding of systemic thinking.   The cases demonstrate that these five student participants attuned to the above processes and in their own way stimulated an epistemic self-transformation.

However, it remains to be demonstrated that their unique experiences, when taken together, indicate the kind of epistemic development integral to the development of systemic thought. I shall attend to this task in this section. I anticipate that this examination will help to further contextualise the student participants' epistemic self-transformations in relation to the patterns of epistemic development identified in systems education literature.

Following the rationale developed earlier (See Section 6.1 above), my purpose here is to draw attention to specific instances from within the narratives of Chuck, Leah, Samara, Pia, and Viggo that appear to be crucial developmental moments in their engagement with systemic thinking. By that I mean those moments in particular wherein each student participant experiences a qualitative transformation, while practicing to think systemically he or she decides to undertake a "structural reorganisation" of their personal worldviews and premises (Salner, 1986, p. 227).

We shall first attend to Chuck's narrative. I present both the evidence and associated reasoning that strongly suggests that Chuck experienced one such crucial developmental moment. Thereupon, I shall draw parallels with similar features found in the narrative accounts of the other four student participants.

Chuck, for example, distinctly recalls being astonished and boggled when as he listened to the diverse work experiences of fellow international students in his group. He immediately recognised how their experiences were in direct contrast to his own

experience. Such a discursive situation is likely to be transformative when one's worldviews are perceived to be incongruent to those of others in that situation and invoke a need to become critically reflective of his or her own worldviews (Mezirow, 1990, 2000, 2009).

Chuck experienced precisely this when he identified a pattern in those experiences that was anomalous to his own. His narrative clearly indicates an awareness of his own way of thinking and doing, those of others, and his initiative to understand and appreciate differences between those ways of thinking and doing (Fordyce, 1988; Sandelin, 1991). He states emphatically that he was glad and grateful for being party to that discussion. It gave him a better perspective of his own vacation work experience, and led him to understand and appreciate it better.

What was, prior to the discussion and personal reflection, perceived as pervasive and highly ingrained culture and practice of safety, now seemed to be worth the tedium entailed. It appeared sensible to him in that he realised that the company that hired him and the company he was contracted to during his stint recognised their corporate-social-ethical-environmental responsibility and took it seriously. Systemically, it made good sense.

Even though he encountered worldviews about safety culture different to his own, he chose to exercise both openness and inclusivity. He was open and inclusive in the sense that he did not devalue the validity of those opposing worldviews. Instead without being entirely fixated on his own worldviews, he decides to evaluate and modify his own understanding. He takes the opportunity to construct a more-informed understanding of safety culture as a result of a widening of his personal worldview.

As a result of that discussion, he recognises and understands the benefit of being inclusive of multiple and possibly conflicting or contradictory perspectives because when integrated they allow one to rigorously understand the complexity of a situation in terms of issues, effects and influences. This kind of openness and inclusivity are vital attitudinal prerequisites for systemic thinking (Cavaleri, 2005; Checkland, 1999; Churchman, 1968; Salner, 1986; Wilson, 1973).

But more definitively, they are strongly suggestive of the responses and outcomes of a sequence of transformative developmental moments that first "precipitate" when a person confronts the existence of multiple valid perspectives in the course of a

discursive situation as above, and subsequently culminate such that the person becomes more inclusive, discerning, open, reflective, and emotionally able to change (Mezirow, 1990, 2000, 2009).

A similar sequence of transformative developmental moments can be noticed in the narratives of Leah and Samara. I shall first review Leah's evidence; this is followed by a review of Samara's account. Since the same reasoning applies to these two instances as identified in Chuck's case above, I shall avoid re-citing the references from the literature in the course of the reviews below.

In Leah's narrative, the anomalous instance emerged from the dynamics of the discussion. She entered into her own group's discussion well-informed about thinking through issues systemically. It appears that her group members too were decisive and effective in undertaking the discussion to achieve their intended ends. In the course of an intergroup discussion, she observed not only that individuals think differently, groups do too. Entire groups can have contradictory or conflicting perspectives.

This instance precipitated in her grasping the practical logic of how group constitution can influence the resolution of perspectives regarding issues in general. In a self-selected group, as she observed, parity among perspectives is a more likely occurrence when the familiarity of group members inclines the entire group toward achieving consensus. A flock mentality can result. This, in Leah's understanding, is not necessarily an effective strategy for the purposes of systemic thinking where the express interest is to see interconnections and examine the influences and effects of interactions (Espejo, 1994). Nor does it allow for critical reflection where the imperative is to compare and contrast divergent perspectives.

The inclination toward consensus-building is likely to marginalize divergent perspectives as well as individual members who have divergent perspectives. Leah's classroom discussion experience later revealed that intergroup discussions remedied such an occurrence, because entire groups can and often do converge on those same marginalised perspectives.

When such groups come together the very marginality of some perspectives over others becomes moot and is likely to generate further insight into whatever issue is being addressed. In actively engaging in, critically observing, and reflecting on the anomalous dynamics of the unfolding discursive process, Leah noted patterns of inclusions and

omissions of perspectives through intergroup discussions and their significance to the systemic thinking enterprise.

Samara, too, like Leah, had constructed her own understanding of the process involved in systemic thought. To her, quintessentially it required one to have a holistic frame of mind, attuned to the appreciation of relationships and interconnections, and identifying and understanding perspectival similarities and differences in order to gain a wholesome understanding of whatever is under scrutiny.

Her anomalous instance emerged in the course of discussions within her group wherein most of the time she agreed with others on topical matters, there were still others in which she found herself puzzling over the reasoning of other members. One such occurrence stood out in her memory because she describes finding it both interesting and difficult to grasp why other group members supported a view that seemed unreasonable to her. She proceeded to listen to her fellow group members and came to appreciate their reasoning.

What at first seemed unreasonable to her, upon listening with an interest to genuinely understand, it now appeared to be reasonable. That instance precipitated in an important personal insight for her. It was that those with alternative worldviews to one's own may be correct in holding their worldviews. By exploring the reasoning behind those worldviews it is possible to recognise and appreciate other people's logic.

Her openness to listen to her group members' views enabled her to recognise that the validity of conflicting worldviews can be determined by the consideration of the context within which they arise. That instance forcefully demonstrated to her the need of and virtue in empathetic listening in the process of systemic deliberation.

Like Chuck, Leah and Samara too encountered an anomalous instance in the course of their workshop discussion. The instances precipitated in different ways for each of them. However, what is noteworthy here is that their narratives, unique as they are, when juxtaposed appear to exhibit the same transformative responses and outcomes. They became critically reflective, each in their own way, amid their respective discursive situations.

This resulted owing to their recognition of the fact that their personal worldviews or those of their respective groups were contrary to those of others. They then elected to construct a clearer understanding of their own views by examining the viability of their

own beliefs and attitudes. This was largely owing to triggers arising from the arguments during their discussions, given that such discursive situations are widely recognised for their transformative potential (Bawden, 2010; Mezirow & Associates, 1990, 2000) and their ability to loosen the grip of "limiting worldviews" (Salner, 1986, p. 232).

Pia and Viggo also experienced a sequence of transformative developmental moments. However, they did not encounter an anomalous instance in their respective workshop discussions. Transformative moments can also "precipitate" when a person encounters a situation that presents itself as a disorienting dilemma (Mezirow, 1990, pp. 13-14). Moments of this kind also incite the person to examine his or her own worldviews. However, the examination undertaken serves a different purpose. It prompts the person to seek meaningful reasons to arrive at a better, more informed, and contextually-appropriate judgement about the situation being confronted (Mezirow, 1990, 2000, 2009). Both Pia and Viggo appear to experience transformative developmental moments owing to an encounter with a situation as described above.

Pia's narrative, for example, highlights that one of her immediate concerns was how to comment on other people's blogs in an ethically responsible manner. This situation presented itself to her as a disorienting dilemma in that she found it imperative to comment constructively and yet hard to actually do so. It was a practical challenge. She was aware that personal worldviews are situation and context-bound and that actions resulting from those worldviews are, therefore, situationally and contextually appropriate.

The problem, as she saw it, was in the possibility of formulating distorted worldviews and how to handle personal encounters with distorted worldviews. She knew that everyone – herself included – is susceptible to such distortions, which are likely to be grounded in distorted premises (Mezirow, 1990, pp. 14-17). She had to figure out a practical way that allowed for those distortions to be highlighted in a meaningful and respectable manner when blogging and commenting but avoiding being and being perceived by others as judgemental.

Her narrative clearly exhibits how in that situation she practically reasoned her way to arrive at an ethically sound resolution to her dilemma (Dunne & Pendlebury, 2003). Consequently, she formulated a commenting approach that demonstrated an empathetic and open-minded stance. In her own way, drawing on her own powers of

reasoning, she realised that the most appropriate and mature manner of managing possible worldview distortions was to engage in critical discourse (Mezirow, 1990).

Viggo encountered his disorientating dilemma when he had to respond to the final reflective blog. It became critically apparent to him that he needed to invest time and attention in order to dispel his confusion about systematic and systemic thinking. It precipitated into his decision to execute an online search for information to assist him to better understand the concept of systemic thinking.

He realised that there are in existence multiple perspectives and definitions on systemic thinking and that he had to arrive at one which resonated with his own understanding. Following Bartlett (2001), he construed systemic thinking as a part analytical and part synthetic exercise to generate greater clarity and understanding about a topic of interest by attending to relationships and interconnections between the various conceptual elements that constitute it.

He realised in that process that systemic thinking required him to think differently to the way he was accustomed to. His narrative clearly demonstrates that in striving to engage systemically he noted the need to deliberately and repeatedly examine his thought process and that as a result he better understood topical issues in PRM.

This insight is congruent with findings in systems literature. A systemic thinker must actively examine his or her own thinking, and attend to what is thought about and how it is being thought about (Cavaleri, 2005; Checkland, 1999; Churchman, 1968, 1970; Salner, 1986). In taking the time to apply his understanding of systemic thinking to the reflective blogging task, and practically reasoning as he did, Viggo also came away with a nuanced understanding of systemic thinking as an approach by which complex problems can be resolved.

But this needed, as he reasoned, an open-minded and inclusive stance toward shared understanding of the perceived boundaries of the problem situation (Churchman, 1968; Midgley, 2000). And it also required an acknowledgement of the time-intensive nature of the problem definition process as well as recognition that a systemic thinker's view however broad it may be is still always a partial view, not the focused and detailed view of an expert (Churchman, 1968).

The foregoing examination and the narratives presented in the preceding section clearly exhibit the precipitation of a sequence of transformative developmental moments

experienced by Chuck, Leah, Samara, Pia, and Viggo. All five student participants evidently appear to confront a unique dialogic and discursive situation. Their immediate circumstance catalytically incites critical self-reflection, eventuates in a perspective transformation, and culminates with each student seemingly becoming more inclusive of the worldviews of others, discerning, open-minded, reflective, and flexible regarding their perspectives, positions and stances (Mezirow, 1990, 2000, 2009).

Their narratives indicate a clear awareness of their own ways of thinking and doing, those of others, and they also demonstrate an initiative to understand and appreciate the differences between these ways of thinking and doing (Fordyce, 1988; Sandelin, 1991). When they encountered worldviews different to their own, each student decided to exercise both openness and criticalness, which are essential attitudinal prerequisites for systemic thinking (Bawden, 2005, 2007; Churchman, 1968; Salner, 1986; Wilson, 1973). Such a sequence of transformative developmental moments is also simultaneously a sequence of epistemological developmental moments (Kegan, 1982, 1994, 2000, 2009).

7 Construing and Implementing Systems Thinking in the study of PRM: Concluding Discussion

I undertook my inquiry into the educational principles and practices for the development of systems thinking in PRM as a direct consequence of a set of classroom experiences back in 2009. I was baffled that my students conflated systems thinking and engineering problem-solving, felt they knew and did systems thinking routinely in their engineering study, and yet ignored the consideration of contexts, interrelationships and interactions in PRM situations (See Chapter Section 1.1).

Systems thinking became a curious phenomenon. I was also curious about how systems thinking can be taught, learned, assessed and evaluated in PRM. My inquiry was a means to address these curiosities; my guiding questions were a means to orient the inquiry in relation to those curiosities (See Chapter Section 1.2). They were:

1. How can systems thinking be construed in the study of PRM situations?
2. How can systems thinking be implemented in the study of PRM situations? Or, what kind of pedagogic and assessment practices does an educator need to implement to encourage systems thinking in the study of PRM situations?
3. How can an educator ascertain that students are engaging in systems thinking in the study of PRM situations? Or, what kind of evidence does an educator need to gather to ascertain that students are engaging in systems thinking in the study of PRM situations?

Every inquiry proceeds in a certain way as a result of its guiding methodology. And its methodology entitles the inquirer to speak about the inquiry in a specific way. I proceeded hermeneutically (See Chapter Section 2.1), desirous of cultivating a deeper, nuanced, and transformative understanding of the practices that drew my attention – teaching, learning, assessing and evaluating systems thinking in the study of PRM.

This thesis, particularly this concluding chapter, is the culmination of an intense six-year long inquiry. In the following three sections I revisit the above guiding questions and briefly highlight the insights that flashed forth in the pursuit of each line of inquiry. The section thereafter focuses on a set of recommendations that I have developed as a result of my inquiry. And in the final section, I bring the thesis to a close by highlighting

some constraints of my inquiry, and subsequently summarise my contributions to the topic of inquiry.

7.1 How can systems thinking be construed in the study of PRM situations?

In so framing this first guiding question, I explicitly prioritised the fact that a truly meaningful and productive endeavour to implement the development of systems thinking in a unit at the classroom level cannot ignore the issue of conceptualisation. Our perception of what a particular competence *is* has a direct impact on how it is taught, learned, assessed and evaluated. Conceptualisation is the primary imperative, the "logical starting point" (Barrie, 2007; Hughes & Barrie, 2010, p. 328).

Conceptualisation pays due regard to another fact: a competence can (and often does) mean different things to different people in different disciplines (Jones, 2009). This has been the case for critical thinking (Ahern, O'Connor, McRuairc, McNamara, & O'Donnell, 2012; Bailin & Siegel, 2003; James, Hughes, & Cappa, 2010; Jones, 2007; Macpherson & Owen, 2010; Moon, 2008; T. J. Moore, 2011).

And so too, with systems thinking (Barton, et al., 2004; Bawden, 1991; Boersma, Waarlo, & Klaassen, 2011; Cattano, et al., 2011; Cavaleri, 2005; Checkland, 1999; Flood, 2001; Fordyce, 1988; Fox, 2009; Hadgraft, et al., 2008; Jackson, 2000; Kellam, et al., 2008; Midgley, 2003; Nehdi & Rehan, 2007; Trochim, Cabrera, Milstein, Gallagher, & Leischow, 2006).

I deliberately undertook conceptualisation of systems thinking in the study of PRM, mindful of the fact that lack of attention to this key step has been recognised as one of the key reasons for the dearth of research and discourse on development of systems thinking in engineering education (Carew & Therese, 2007; Carew, et al., 2009; Hadgraft, et al., 2008).

Conceptualising systems thinking in the study of PRM provided a hermeneutic opportunity to harness insights through the cross-fertilisation of systems ideas from engineering and non-engineering disciplines.

As a result, I argued in Chapter 3, that one possible approach to develop systems thinking in the study of PRM is to construe and communicate it as an epistemic process of coming to understand the complexity and ill-structured nature of a PRM situation. I

suggested that to engage in systems thinking requires a shift toward thinking systemically; and that this shift involves the practice of two methodological commitments.

I proposed that systemically thinking about any given PRM situation meant:

- Recognising, appreciating, and including multiple perspectives or viewpoints (which may be contradictory) so as to evaluate the beliefs and values that motivate them; and
- Exercising critical self-reflexivity, social and ethical awareness when examining a PRM situation. When students practice these commitments they will be thinking in similar ways to professional process risk managers.

7.2 How can systems thinking be implemented in the study of PRM situations?

In so framing the next guiding question, I explicitly prioritised the fact that a truly meaningful and productive endeavour to implement the development of systems thinking in a unit at the classroom level must holistically address the issue of pedagogy and assessment.

In the arena of higher and professional education, educators have been increasingly encouraged to construe teaching, learning, and assessment as relational practices in the process of education. The emphasis is on teaching such that learning can happen (Boshier & Huang, 2008; Bransford, et al., 2002; Edwards, 2006; Fitzmaurice, 2010; Haggis, 2009) and assessments that promotes learning (Havnes & McDowell, 2008; Joughin, 2010; Taras & Davies, 2013).

This relational perspective is also reinforced in literature on educational competence development more generally (Dall'Alba, 1994, 2004; Dall'alba & Barnacle, 2007; Dall'Alba & Sandberg, 1996; Illeris, 2009d), and specifically in competence development in engineering education literature as well (Gattie, et al., 2011; Litzinger, et al., 2011; Walther, et al., 2011).

Educators interested in educational competence development are increasingly adopting activity-based approaches because they provide the necessary relational context where pedagogy and assessment practices jointly foster the development of a competence. But

this is complicated by the fact that multiple competences can be fostered simultaneously through the same activity.

For example, activity-based approaches like problem- and project-based learning are known to foster complex problem-solving skills, professional judgement and decision making, as well as practical and ethical reasoning (Dall'Alba & Sandberg, 1996; Illeris, 2009d; Litzinger, et al., 2011).

If a particular kind of competence needs to be developed through an activity-based approach, then the onus is on the educator to examine the possibility of customising the activity. What aspects of an activity done in a certain way are likely to foster students' development of that competence?

This kind of examination is particularly crucial in the case of systems thinking because it is recognised as a "meta-attribute", a competence which taps into the same kind of awareness which underpins other competences like reflective practice, lifelong learning, innovation, creativity, openness and a sense of social justice (Hadgraft, et al., 2008, p. 43).

I deliberately undertook the examination of the above issue in Chapter 4, mindful of the fact that lack of ownership and responsibility to critically re-examine pedagogic and assessment practices that authentically engage students in systems thinking has been recognised as another key reason for the dearth of research and discourse on development of systems thinking in engineering education (Carew & Therese, 2007; Carew, et al., 2009; Hadgraft, et al., 2008). As these researchers have observed, habituation to educating in particular ways has detracted educators from serious reconsideration of their educational practices. I resisted this detraction in my inquiry.

In Chapter 4, I examined the principles and practices of educational competence development, and drew inferences regarding my role and responsibilities in developing systems thinking in the study of PRM. I needed to:

- Provide students with learning opportunities where my students and I can actively inquire into our ways of thinking to examine preconceptions, differences and patterns of thoughts;
- Ensure those learning opportunities provide students occasions to understand how PRM theory and practices can be productively applied to think systemically in PRM situations;

- Treat all such learning opportunities as formative encounters and offer students ongoing feedback that is positioned as advice rather than instruction; and

- Foster community learning through group work whereby students can collectively evaluate personal reasoning, notice and examine differences in reasoning and perspectives, question premises, and experience ontological, epistemological and methodological dilemmas which can prompt deeper and deliberate thinking.

In Chapter 4 I also explored the possibility of customising the activity-based approach to foster systems thinking. I reasoned that students are more likely to engage and develop their ability to think systemically when they actively practice it. But I also argued that if the students are to truly learn and understand systems thinking then there must be an emphasis on judgments, decision-making, and individual and social reflection.

I explained that this emphasis is particularly vital to the engagement and development of systemic thinking because such activities are likely to invoke epistemic development, which is critical to the development of students' systemic sensibilities.

Subsequently, I reasoned that epistemic development is likely when PRM activities involve:

- Engagement with ill-structured risk and safety oriented problems;
- Opportunities for students to examine different points of view on a topic;
- Opportunities that encourage students to make judgments and to explain what they believe;
- Opportunities for students to critically reflect upon personal and collective epistemic assumptions; and
- Opportunities that make the PRM content conceptually transparent to the students such that the links and the relationships between various PRM concepts, principles and practices become clear.

Lastly I identified that a range of activities are currently available which provide a suitable context for epistemic development as well as the practice of systemic thinking. These include activities such as the resolution of ill-structured problems through group discussions, debates, presentations, case based teaching, reflective journals, and concept mapping.

7.3 How can an educator ascertain that students are engaging in systems thinking in the study of PRM situations?

In so framing the last guiding question, I explicitly prioritised the fact that a truly meaningful and productive endeavour to implement the development of systems thinking in a unit at the classroom level must holistically address the issue of whether learning has occurred.

It is important to point out that there was a deliberate choice of words involved in the framing of the guiding question. I focus on whether students are "engaging", and there is an emphasis on "learning" rather than "development". I chose this framing with good reason.

By the time I had progressed in my inquiry along the lines of the preceding guiding questions, my own understanding about competence development in general, and systems thinking in particular, had undergone a significant change. It had become clear to me that in higher and professional education a peculiar dynamic was at work.

Discourse and research on teaching and learning tends to veer toward evaluation of teaching, rather than learning. Similarly, discourse and research on assessment leans toward assessment *of* learning rather than assessment *for* learning. Learning, and evaluation of learning takes a back seat, even though the rhetoric is oriented around learning.

But, this preference is increasingly being challenged, and many educators are deliberately foregrounding learning (Boshier & Huang, 2008; Boud & Falchikov, 2007; Haggis, 2011; Joughin, 2010; Price, Carroll, et al., 2011). And this is evident even in educational competence development in higher and professional education (Barnett, 2004, 2007, 2009; Dall'alba & Barnacle, 2007; Illeris, 2011c, 2009d; Knight, 2007).

The problem, however, is that there is a dearth of discourse on and examples of evaluation of learning, especially in educational competence development in higher and professional education. But this, too, is unsurprising given the contemporary understanding of the educational principles of competence development. Competence development is construed as a complex and holistic, situative, emergent, sociocultural, and constructive-developmental process (See Chapter Section 4.1).

This introduces constraints on attempts to evaluate the learning or development of any competence, especially at the classroom and unit level – which is a focus of my inquiry. A competence is more likely to be developed over longer time periods rather than weeks, and its development is unpredictable, uncertain, non-linear, and indeterminate (Illeris, 2009a; Jarvis, 2009; Knight, 2007; Litzinger, et al., 2011; Sundberg, 2001; Walther, et al., 2011). This is true for systems thinking too (Bawden, 2003, 2005, 2007; Salner, 1986; Sundberg, 2001).

So evaluation of learning calls for a different focus and emphasis. But exactly what this focus and emphasis must be is rarely discussed, nor is there discussion about what counts as evidence of learning. This dearth of discourse and lack of examples of evaluation of learning is acutely apparent in the evaluation of learning to do systems thinking - whether it is in PRM in particular; in chemical engineering or other engineering disciplines; or even in disciplines beyond engineering

It was clear to me, however, that I needed to realistically and pragmatically "warrant that learning has occurred" (Boud, 2010, p. 39; Knight, 2007). And I construed the above challenge as an opportunity to hermeneutically inquire into what can validly count as evidence of learning to do systems thinking in the study of PRM at a classroom level.

I found that it makes good sense to focus on two main aspects of learning to do systems thinking. The first aspect centred on what I have defined as the performative aspect of practicing systems thinking (See Chapter 5). My emphasis was on gathering evidence that suggested students were engaging and participating in the opportunities to apply the two methodological commitments involved in thinking systemically in the study of PRM situations (which I have defined in Chapter 3). In doing so, I drew on the situative-constructive and emergent aspects of learning involved in systems thinking in the study of PRM situations in an activity-oriented assessment approach (See Chapter 5).

The second aspect centred on what I have argued to be the transformative aspect of practicing systems thinking (See Chapter 6). The transformative aspect refers to the "personal transformation that occurs as someone learns" to apply a competence (Jones, 2009, p. 95). My emphasis was on gathering evidence of evidence of self-transformation in the course of epistemic development (Bawden, 2003, 2005, 2007, 2010; Bawden, et al., 2007; Mezirow & Associates, 1990, 2000; Salner, 1986).

More specifically, I gathered evidence of those instances and moments instances when upon encountering a discursive situation (in the course of their engagement in an activity-oriented assessment) perceived as anomalous or as one that presents a disorienting dilemma, a student compelled oneself to become critically reflective, and became more inclusive, discerning, open, reflective and emotionally receptive to change in the process of engagement (Mezirow, 2009; Mezirow & Associates, 1990, 2000).

I also found it particularly useful to analysis, interpret, and present this corpus of evidence using narratives. Narratives are an effective means to showcase both the performative and transformative aspects of learning to think systemically in the study of PRM (See rational provided in Chapter 2.2). They are increasingly accepted to be well suited to capture the complexities of competence development in general (Beckett, 2004, 2009; Beckett & Hager, 2000; Clandinin & Connelly, 1991; Connelly & Clandinin, 1988, 1990; Dunne & Pendlebury, 2003; Gudmundsdottir, 1995, 2001; Pendlebury, 1995; Perrotta, 2009), and the development of holistic or systemic thought in particular (Mattingly, 1991; Schön, 1983, 1987, 1991b; Tsoukas & Hatch, 2001).

7.4   Recommendations of this Inquiry

It has been suggested that for educational research to be truly educational, it ought to be pragmatic (Davis & Phelps, 2006). Educational research ought to influence educational practice. In this section, I draw on lessons from my experiences in the conduct of this educational inquiry. These lessons can serve as recommendations to fellow engineering educators.

I sought to resolve a practical question: What we ought to understand when teaching systems thinking in process risk management education? Chapters 3-6 of this thesis meaningfully contribute to the resolution of the above question. These chapters also suggest lessons that are applicable to competence development at the classroom level in general:

Firstly, competence development at the classroom level in engineering education can be construed as a hermeneutic (interpretive) practice. An engineering educator interested in developing a particular competence in a classroom setting would do well to recognise that *that* competence means different things to different people. It is understood in different ways within one's discipline and beyond it. An important and meaningful way ahead in such a case is to invest attention on interpreting and "repurposing" what a

competence means in his or her context in relation to the definitions found within and beyond the engineering discipline.

Secondly, competence development at the classroom level in engineering education can be construed as a practice of teaching and learning a competence as a set of commitments to thinking, being, and acting in a certain way in any given situation. It is the educator's responsibility to define, communicate, and model what these commitments are likely to be in the context of his or her specific unit

Thirdly, competence development at the classroom level in engineering education can be construed as a practice of teaching and learning a competence when students have ample opportunities to exercise the above commitments. A competence is best understood and refined through reflective practice. Greater the number of opportunities offered to exercise those commitments, the greater the likelihood that the students will understand the relevance and necessity of a competence to the subject concerned.

Fourthly, competence development at the classroom level in engineering education can be construed as a practice of teaching and learning a competence where assessments serve as formative, performative, and transformative means by which students refine their practice and understanding of the competence in question.

Fifthly, competence development at the classroom level in engineering education can be construed as a practice of teaching and learning a competence where evaluation of learning of a competence encompasses both the performative and transformative aspects of a competence. Although a competence is learned and mastered over a prolonged period of time, each practice experience is likely to change a student's degree of competence as well as his or her understanding of that competence. These changes are best demonstrated narratively because narratives effectively showcase a competence being performed in the context of a given assessment practice, and they are just as effective in highlighting qualitative changes to understanding as a result of engaging in a given assessment practice.

The above lessons can only be construed as generic and nonprescriptive recommendations emerging from the conduct of my educational inquiry. This is as it should be. All educational inquiries of a qualitative kind are situated, contextual, and emergent. Lessons learned from such inquiries are local, specific, and contextual. This

limits their generalisability and applicability. Fellow educators are invited to apply these recommendations by appropriating my lessons as best as possible to their own contexts.

7.5   Constraints of this Inquiry

These recommendations as well as the inquiry from which they arise are limited by my own limitations both as an educator as well as a doctoral educational inquirer. Flaws in conceptualisation of the inquiry are likely to generate flaws in the conduct of this inquiry. Similarly, flaws in conceptualisation of a competence are likely to generate flaws in the practices to develop that competence. I have actively sought to address such occurrences by practicing the very commitments I have proposed in this thesis. I have sought to think systemically throughout the conduct of my inquiry and also in my teaching and competence development endeavours in the classroom. I have explicitly highlighted my reasons and justifications in relation to what I believe to be ethically defensible decisions, actions, and practices in specific contexts. This has been done so that any flaws in conceptualisation can be detected and addressed in future research endeavours.

Another kind of constraint is introduced as a result of the choice of inquiry approach and the topic of inquiry. A hermeneutic inquiry is perspectival, context-sensitive, and aims for a detailed, descriptively articulated understanding of the topic of inquiry which does not claim to be comprehensive (Packer, 1985). It acknowledges and treats the topic of inquiry in a manner that respectfully presents its inherent ambiguity and complexity.

Competence development can be an ambiguous and complex enterprise because a competence can be framed, reframed, and interpreted in multiple ways, and it has a significant tacit dimension (Jones, 2009). How a particular educator and educational inquirer interprets a competence introduces constraints on how it can be subsequently taught, learned, assessed and evaluated (Barrie, 2006, 2007; Hughes & Barrie, 2010; Neumann & Becher, 2002). This is true for systems thinking too. Another engineering educator and educational inquirer approaching this topic could frame systems thinking differently and develop an alternative set of educational frameworks for pedagogy, assessment, and evaluation.

As this thesis demonstrates, I have framed systems thinking in a specific way for the purposes of study in PRM situations at a classroom level. I think of systems thinking as an epistemic competence which enables a person to meaningfully understand the

complexity and ill-structured nature of a PRM situation. I see it as a methodology by which a person can learn about a PRM situation by focussing on examining the multiple perspectives of the social actors participating and interacting in value- and interest-driven ways to bring about the complexity and ill-structuredness of a given PRM situation. And I have construed this learning methodology as one that requires my students to exercise two commitments. The first commitment is toward recognising, appreciating, and including multiple perspectives or viewpoints (which may be contradictory) so as to evaluate the beliefs and values that motivate them. And the second commitment is toward exercising critical self-reflexivity, social and ethical awareness when examining a PRM situation. When students practice these commitments they will be thinking in similar ways to professional process risk managers. I have carefully developed my pedagogic, assessment and evaluative frameworks around my framing of systems thinking. I found in the course of my inquiry that this framing of systems thinking and the resulting educational framework was productive in my context. But I do not offer my frameworks as normative. Rather, the frameworks provide one way of approaching the topic of inquiry.

7.6   Ethics of this Inquiry

At Curtin University, any research inquiry that involves humans as participants must receive approval from the University's Human Research Ethics Committee (HREC). Doctoral inquirers cannot undertake any aspect of their inquiry with participants without an approval number. The approval number for my inquiry is SMEC-72-10. The approval is granted only when the inquirer's application demonstrates an understanding of the Australian Code for the Responsible Conduct of Research, a living document that is updated regularly by the National Health and Medical Research Council (NHMRC). The inquirer is expected to abide by that code. In addition to the code, the NHMRC also sets the ethical standards for all research involving humans. These standards are found in the National Statement on Ethical Conduct in Human Research. The inquirer is also expected to always conduct his or her inquiry in compliance with ethical standards in Australia.

In the following paragraphs I describe key decisions and judgements which informed my action plan to conduct an ethically minded inquiry that involved the participation of university undergraduates. I submitted this action plan as a part of my Application for Ethical Approval of a Research Project Involving Humans at Curtin University. This application was approved by Curtin University's Human Research Ethics Committee

(Appendix 21).The descriptions provided below address three main areas emerging from my understanding of the above mentioned code and ethical standards: (a) gathering informed consent to participate in research projects, (b) protection of privacy and confidentiality of records, (c) risk of harm to subjects or to groups in the community.

Gathering informed consent to participate in research projects

My inquiry was situated within the Department of Chemical Engineering at Curtin University, in the fourth year unit of PRM. Large numbers of undergraduate students enrol in this unit; a small number of postgraduates also enrolled in it. There were approximately 120 students enrolled in PRM at the time. Undergraduate students were expected to be 20 years and over. The enrolled cohort was a mix of Australian and international students of diverse cultural and ethnic backgrounds. It was anticipated at least 5-10 willing and enthusiastic students from the entire classroom cohort would volunteer to participate in my inquiry.

Each student who attended the PRM introductory class during Orientation Week 1 of the teaching semester was presented two documents that served as an invitation to participate in the inquiry. The first document was a Participant Information Sheet. This two-page document provided detailed information regarding the context of inquiry, its aims and intentions, evidence gathering activities, possible benefits of participation, and intended outcomes of my inquiry. All of the above information was also verbally communicated to the students in the same introductory session. The students were informed that they have an opportunity to ask any questions about the inquiry at any point of time in the course of the inquiry. I told the students that their participation was entirely voluntary, and they had the right to withdraw from the inquiry at any time, without prejudice or negative consequences. They were also assured that no aspect of the inquiry would be used in determining their final grade in the unit.

Students were then asked to examine the second document, a Participant Informed Consent Form. Students were told that if they were interested in participating in this inquiry, this second document would be the official way to express their interest and give their consent. Signing on the Participant Informed Consent Form indicated that each participant: (a) was informed to his or her satisfaction about the educational inquiry to be conducted in PRM; (b) understood and accepted that the inquiry would involve their participation in classroom observation, audio-taped individual and focus group discussion, provision of sample assessment response, questionnaires and unit

evaluation surveys; (c)agreed to participate voluntary in the inquiry and reserved the right to withdraw consent at any time without prejudice; and (d) understood that all evidence gathered from them would be non-identifiable when used and would be securely stored for at least 5 years before a decision is made as to whether it should be destroyed.

Both documents provided contact details of the inquirer and his supervisor in case participants wanted to better understand their roles and responsibilities as participants in this inquiry. The documents also informed the students that the inquiry was approved by the Curtin University Human Research Ethics Committee (HREC)'s ethics approval number was clearly printed in bold. In addition, contact information of the HREC was also furnished in case participants wanted to report a complaint on ethical grounds. The students were subsequently invited to participate in my inquiry and to consider giving their consent. Students were not directly or indirectly pressured or coerced into participation. An administrative staff member (who acted as a third party) was asked to collect signed consent forms. I and my supervisor left he classroom temporarily when this process was undertaken, and returned to it when the process was completed.

Protection of privacy and confidentiality of records

As per the code and the ethical standards mentioned above, it is vital to ensure the privacy of individuals and the confidentiality of evidence obtained. It was important that prior to engaging in my inquiry I ascertain ways by which to assure the privacy of the participants of my inquiry and the confidentiality of all evidence obtained about and gathered from my participants. This was a matter of concern given that students enrolled in PRM (particularly those who consented to participate in the inquiry) were identified as being in a dependent and unequal situation. I was both inquirer and tutor in the PRM unit. Mindful of the fact that my participants could be Australians and international students with diverse cultural and ethnic backgrounds, I chose to deliberately avoid making the cultural and ethnic identity of participants as a criterion of my inquiry. All evidence gathered and processed in the inquiry was made non-identifiable, and pseudonyms were to be used throughout the thesis and other future publications arising from it. Raw evidence gathered during the inquiry was to be stored for a period of 5 years before a decision is made as to whether the evidence will be destroyed. Only I and my supervisor had access to this evidence, and it was stored electronically on a computer which is password authenticated. This evidence was regularly backed up on personal usb devices.

Risk of harm to subjects or to groups in the community

My inquiry posed no perceivable risk of harm to individuals or groups in the community. This was because the inquiry made no use of new and untried procedures, invasive procedures, administration of drugs, or the use of procedures to cause pain or suffering. The inquiry did not threaten the cultural security of any participants, nor were there processes which might expose the participants to discrimination or misrepresentation.

However, this was an educational inquiry conducted in a university setting with undergraduates with whom I also shared a tutor-student relationship. This situation was identified as being a dependent situation wherein there exists an unequal power relationship. This dimension of the inquiry was unavoidable. It was important, therefore, to account for it and develop inquiry strategies that did not pose risk of harm, partiality, and unfairness in the above professional relationship. I engaged in my role as tutor, mindful of Curtin University's policies about ethical workplace conduct. My doctoral supervisor (who was also the unit coordination, lecturer, and fellow tutor in PRM) was the final arbiter of all marks and grades I allocated for students' assessments. I regularly discussed such issues with her, and raised my concerns whenever they arose in the course of teaching and inquiry. For the purpose of my inquiry, she was also a vital point of contact for my participants whenever they needed to discuss or seek additional information about the inquiry process. My supervisor and I, informed and guided by institutional codes of conduct and our individual sense of ethic and fairness, engaged in our professional responsibilities. We maintained clear, open, and transparent lines of communication between ourselves as well as the students in our care.

For example, I exhibited no bias against any student and did not consider any participant other than those who were being observed in their normal classroom environment where such observation was considered innocuous. The cultural and ethnic background of the participants was not a criterion of the research and was rendered non-identifiable in this thesis. Evidence was gathered from participants within the university campus during daily business hours in easily accessible public venues. Meetings for the focus group discussions, for example, were scheduled as per participants' convenience at times that did not clash with exams and test study periods. There was minimal disruption to the normal state of affairs during my evidence gathering activities.

Some might argue that this inquiry situation poses a conflict of interest. I would argue that defining the situation in those terms is merely one possible way of conceptualising

it. Instead, I perceived the situation as manifesting dual or complementary interests. As an inquirer, I chose to abide by the codes of ethical educational inquiry practice; and as a tutor, I chose to abide by the codes of ethical educational practice. In either case, I strove to engage in my dual responsibilities as a critically reflexive practitioner.

Educational inquirers are called upon to engage mindfully with ethical issues that may arise throughout the course of their inquiry (Cohen, Manion, & Morrison, 2007b; Punch, 2009). The discussion presented above demonstrates my efforts to engage in a critically reflexive manner on ethical matters in the conduct of my educational inquiry. I consider ethical issues as an inevitable part of educational inquiry practice. They cannot be eliminated, they must be lived out experientially and call on educational inquirers to respond to their demands with acute awareness, heightened alertness, care, empathy, and sensitivity. Decisions in such cases are judgments-in-contexts (Beckett, 2009) emerging from the exercise of tacit practical and moral reasoning (Dunne & Pendlebury, 2003). It is impossible to anticipate each and every ethical issue prior to the conduct of inquiry. Nor is there a rule book that tells an inquirer to act in the face of each and every ethical inquiry situation. As a hermeneutic inquirer, I have strived to make the most-informed decision I could in every situation that presented itself to me, and enacted "responsibly and responsively" (Moules, McCaffrey, Field, & Laing, 2015, p. 178). The thesis - the manner in which it treats the gathered evidence and presents my inquiry and its findings – ought to demonstrate my critically reflexive attitude and stance.

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Appendix 1. Workshop Activity for Systemic Thinking Session Week 3

The Ford Pinto Case

In the 1960's there was strong competition in the American small car market. To be competitive in this market, Ford needed to have a product that had the size and weight of a small car, had a low cost of ownership and clear product superiority. The Ford Pinto went on to become one of the 1970's bestselling cars.

The Ford Pinto was designed to meet these criteria. The strict design specifications were that the car was to weigh less than 2000 pounds and cost less than $2000. Ford also decided on a short production schedule. Instead of the normal time from conception to production of 43 months for a new model, the Pinto was scheduled for 25 months.

Under conditions of reduced product-time to market then tooling up for manufacture which involves making the machines that stamp, press and grind car parts into shape must be done whilst product development is underway rather than after product design. Ford wanted the car in the showrooms with the other 1971 models and tooling had a fixed timeframe of about 18 months.

Investigative journalism by Mother Jones established that:

- 'Ford engineers discovered in pre-production crash tests that rear-end collisions would rupture the Pinto's fuel system extremely easily.'
- 'Because assembly-line machinery was already tooled when engineers found this defect, top Ford officials decided to manufacture the car anyway.'
- 'For more than eight years afterwards, Ford successfully lobbied against a key government safety standard that would have forced the company to change the Pinto's fire prone gas tank.'

It was concluded by Mother Jones from Pinto accident reports and crash test studies that:

'If you ran into that Pinto you were following at over 30 miles per hour, the rear end of the car would buckle like an accordion, right up to the back seat. The tube leading to the gas-tank cap would be ripped away from the tank itself, and gas would immediately begin sloshing onto the road around the car. The buckled gas tank would be jammed up against the differential housing (that big bulge in the middle of your rear axle), which

contains four sharp, protruding bolts likely to gash holes in the tank and spill still more gas. Now all you need is a spark from a cigarette, ignition, or scraping metal, and both cars would be engulfed in flames. If you gave that Pinto a really good whack – say, at 40 mph – chances are excellent that its doors would jam and you would have to stand by and watch its trapped passengers burn to death.'

An accepted approach b federal Automotive Safety regulators at that time for decision-making was risk/cost benefit analysis. Ford applied this method decide how to treat the fuel tank explosion risk. An internal Ford memo calculated:

The cost at the manufacturing stage to fix the problem was $11 per vehicle and the benefit would be no payouts resulting from the fuel tank explosion risk.

Benefits

- 180 burn deaths, 180 serious injuries, 2100 burned vehicles.
- Unit cost: $200,000 per death, $67,000 per injury, $700 per vehicle.
- Total Benefit (180*$200k) + (180*$67k) + (2100*$700) = $49.5M

Risks/Costs

- Sales: 11 Million cars, 1.5 Million light trucks.
- Unit cost: $11 per vehicle.
- Total cost (12.5*$11) = $137.5M

Ford appear to have decided that it was not 'reasonably practicable' to fix the problem during manufacture. It preferred to 'retain the risk' and make payments as required. There were no Standards for withstanding rear-end collisions at a specified speed until after 1977.

The department of Transportation announced in May 1978 that the Pinto fuel system had a 'safety related defect', Ford recalled 1.5 million Pintos. The modifications included a longer fuel filler neck and a better clamp to keep it securely in the fuel tank, a better gas cap in some models, and placement of a plastic shield between the front of the fuel tank and the differential to protect the tank from the nuts and bolts on the differential

and another along the right corner of the tank to protect it from the right rear shock absorber (Centre for Auto Safety)

The consequences of Ford's actions were significant. Millions of dollars of civil lawsuits were filed against Ford and awarded against the car maker. In 1979 Ford Motor Company was charged with reckless homicide but was acquitted in 1980. The Ford Pinto ceased production within months. The damage to the company has been incalculable and it is conservatively estimated there are over 500 burns deaths to people who would not have been seriously injured if the car had not burst into flames.

Based upon your reading prepare to discuss the following points:

1. What aspects of this scenario appear significantly problematic?
2. Discuss the occurrence of business malpractice, and how and why it affects both the notions of safety and society.
3. Was cost/benefit analysis an appropriate approach for deciding public safety?
4. What inferences can be made regarding beliefs, values, assumptions, and attitudes that appear to emerge from this scenario regarding safety?
5. As an engineer working on the Ford Pinto, what would you consider when making a judgement about what was 'reasonably practicable' for Ford to meet its 'duty of care' responsibilities?
6. What strategies could have been employed to inform the public about the increased safety risks associated with certain types of vehicles?
7. In your opinion, if what Ford presented was bad business thinking, then what would constitute good business thinking?
8. In your group, develop one additional significantly critical question that you would like another group to answer.

Appendix 2.   Workshop Activity for Systemic Thinking Session Week 6

The Kudochem Case

Kudochem is a multinational chemical company producing chemicals for the agriculture industry. Responsibility for engineering issues at the 11 Kudochem chemical plants in Europe, primarily in the UK, Germany and the Czech Republic lies with Kudochem's European Regional Engineering Director, Sally Proctor.

In the early hours of one morning, Sally receives a telephone call informing her that there has been a serious explosion at one of the plants. There have been some injuries, and damage has been done to property several hundred metres from the plant, but there have been no fatalities. The scale of the damage is huge, and the main site of the chemical plant is almost completely destroyed.

In accordance with company policy, an inquiry team is set up, involving company employees as well as independent consultants. After several weeks, the team discovers two possible causes, both relating to a new ammonia production technique for fertiliser, which has recently been introduced in all of Kudochem's plants. They are unable to determine which of these two possible causes are responsible. Given the presence of the flawed procedure in all of Kudochem's plants, it is imperative that the ultimate cause of the explosion is identified, so that urgent steps can be taken to safeguard against similar accidents at other sites.

The inquiry team is very concerned at their inability to determine the cause of the accident. Without this knowledge, it will be impossible to satisfactorily modify the plants in order to prevent future explosions of this kind. They make a radical recommendation: to call a meeting with several competitor companies who are also using the new procedure in their fertilizer plants, in order to share experiences and research findings.

This would be a significant departure from standard practice, and some senior colleagues with commercial responsibilities have reservations. To call the meeting would entail releasing information about the safety lapse, as well as discussing sensitive commercial information with business rivals.

However, it may be the case that other engineers in other companies have encountered problems with the new method for producing ammonia, and could offer help in isolating

the problem. Whilst such a course of action may be unusual in this case there are industries where safety critical information is routinely shared amongst competitors.

Dilemma: You are the European Regional Engineering Director for a multinational chemical company. After an explosion at a chemical plant, you have responsibility for preventing similar accidents at 10 other sites. The inquiry team has been unable to identify the cause with complete accuracy, and they have recommended that you initiate discussions with competitor companies to pool knowledge. This would be unconventional, and would entail significant commercial risk.

What should you do?

1. You could take the advice of the inquiry team, and invite engineers from other chemical companies who are using a similar process to produce ammonia, to come and discuss the accident.
2. You could persevere with the safety inquiry in-house, hire more consultants and attempt to ascertain the precise cause of the accident without involving other companies.
3. You could consider the entire process as too risky, and reconfigure your chemical plants to utilise a different method of ammonia production, perhaps reverting to the older established method.

Discuss the underlying ethical concerns you ought to bear in mind in order to arrive at a contextually appropriate decision regarding the action you must undertake. You may support your reasoning and decision making process with a Statement of Ethical Principles (SEP) that has been provided below.

The Statement of Ethical Principles: The Royal Academy of Engineering, in collaboration with Engineering Council (UK) and a number of the leading professional engineering institutions, has created a Statement of Ethical Principles to which it believes all professional engineers and related bodies should subscribe.

Professional Engineers work to enhance the welfare, health and safety of all whilst paying due regard to the environment and the sustainability of resources. They have made personal and professional commitments to enhance the wellbeing of society through the exploitation of knowledge and the management of creative teams.

This Statement of Ethical Principles sets a standard to which members of the engineering profession should aspire in their working habits and relationships. The Statement is fully compatible with the principles in the UK Government Chief Scientific Adviser's Universal Ethical Code for Scientists, with an emphasis on matters of particular relevance to engineers. The values on which it is based should apply in every situation in which professional engineers exercise their judgement.

There are four fundamental principles that should guide an engineer in achieving the high ideals of professional life. These express the beliefs and values of the profession and are amplified below.

Accuracy and Rigour: Professional engineers have a duty to ensure that they acquire and use wisely and faithfully the knowledge that is relevant to the engineering skills needed in their work in the service of others. They should:

- always act with care and competence
- perform services only in areas of current competence
- keep their knowledge and skills up to date and assist the development of engineering knowledge and skills in others
- not knowingly mislead or allow others to be misled about engineering matters
- present and review engineering evidence, theory and interpretation honestly, accurately and without bias
- identify and evaluate and, where possible, quantify risks.

Honesty and Integrity: Professional engineers should adopt the highest standards of professional conduct, openness, fairness and honesty. They should:

- be alert to the ways in which their work might affect others and duly respect the rights and reputations of other parties
- avoid deceptive acts, take steps to prevent corrupt practices or professional misconduct, and declare conflicts of interest
- reject bribery or improper influence act for each employer or client in a reliable and trustworthy manner.

Respect for life, law and public good: Professional engineers should give due weight to all relevant law, facts and published guidance, and the wider public interest. They should:

- ensure that all work is lawful and justified

- minimise and justify any adverse effect on society or on the natural environment for their own and succeeding generations

- take due account of the limited availability of natural and human resources;

- hold paramount the health and safety of others

- act honourably, responsibly and lawfully and uphold the reputation, standing and dignity of the profession.

Responsible leadership - Listening and informing: Professional engineers should aspire to high standards of leadership in the exploitation and management of technology. They hold a privileged and trusted position in society, and are expected to demonstrate that they are seeking to serve wider society and to be sensitive to public concerns. They should:

- be aware of the issues that engineering and technology raise for society, and listen to the aspirations and concerns of others

- actively promote public awareness and understanding of the impact and

- benefits of engineering achievements

- be objective and truthful in any statement made in their professional capacity.

Appendix 3.   Workshop Activity for Systemic Thinking Session Week 9

The Issue at Hand

Two explosions at a chemical plant in western Japan on Sunday, April 22, 2012, killed one worker and injured 22 others, including plant workers and nearby residents. The blasts occurred at Mitsui Chemicals Iwakuni-Ohtake plant as workers were trying to shut down the factory due to a problem in another section of the plant. Mitsui Chemicals, which is based in Waki in Yamaguchi Prefecture, produces adhesives for wood and rubber tyres.

News media reports inform that the explosion hit the adhesive plant shortly after 2 a.m. local time. A 22-year-old worker was killed and 11 others were injured. The blast broke windows of about 270 buildings, including nearby houses. The hands and heads of six people were cut by broken glass. A second blast occurred in the compound shortly after 8 a.m. local time, but no one was injured.

Mitsui Chemicals has said production at the plant was halted on Saturday after trouble at another plant, which helped avoid large casualties. The fire department and police are investigating what caused the massive explosions. According to the police, there were no dangers of toxic leakage. The flames were brought under control about 15 hours after the second explosion.

News of this latest industrial accident has now reached international shores. CEOs of various industrial operations, including you, have learnt of this. Your company has not experienced any major industrial accidents, and has an excellent corporate reputation. Yet you are concerned, and anticipate that news of such industrial accidents will spook your investors, stakeholders and consumers alike.

In anticipation of an imminent meeting with the board of investors and stakeholders in order to allay their fears, you have convened a special task board meeting to address an important area of concern. To the best of your knowledge and understanding, industrial accidents in the recent past have revealed that although instrumentation issues are largely responsible in major accidents, an underlying issue of safety culture is increasingly being investigated and questioned. It is this area of concern - safety culture, which you and the special task board seek to explore.

It is now widely accepted that workplace safety depends not only on safety management systems but on the development of a safety culture. It is also recognised that management has responsibility and discretion in the way they manage a safety culture at a particular facility.

But the term "safety culture" is open to various interpretations. Owing to your keen business insight you recognise that the "fear" that the investors and stakeholders will be experiencing is largely due to their lack of proper understanding about "safety culture" and how your company views, and more importantly, engages in it.

You envision that since the management team is the face of your company's safety culture initiative, it is best that the special task board communicate their "perspective" through a corporate presentation. The purpose of this meeting is to **plan** the presentation **and** then **discuss the essential elements of "safety culture."** Since all the special task board members have recently attended workshops on risk management, you strongly recommend that the team will be able to satisfactory explore this issue by thinking systemically.

This systemic exploration of safety culture and specific initiatives within your company will be suitable for allaying the fears of investors and stakeholders. You recognise instantly that this "fear" can be remedied through this form of safety assurance. You are free to access any appropriate knowledge or skills you have picked up over the course of the past nine weeks, both from the activities from the Risk Management classes and the Systemic Thinking workshops, in order to explore the notion of safety culture. What it might mean? What you feel it should include, exclude? What makes it work? How and why safety is seen as something "cultural"?

Develop 5 elements (or attributes) you consider appropriate to constitute as indicators of a safety culture. Develop 5 corresponding practices which can be engaged to put the elements in practise.

Appendix 4.   Reflective Blog Exercises for Weeks 3-9

Each participant was required to post a reflective blog in response to their participation in the each session. The reflective blog had an 800-word limit. Bloggers were to write in first person style (I, me, my and so on). Informality in the tone of writing was acceptable. Participants were required to write in full sentences and to use clear, concise language to develop their ideas and responses. They had a fortnight within which to do so. The facilitator and all participants had an opportunity to review these blogs.

Reflective Blog Exercise 1 (Home Activity for Week 3, Online Submission)

Two articles from the The Chemical Engineer from the past 5 years were provided for additional home reading. They were made available on Blackboard, under the Reflective Journal section. The participants were asked to choose one of them, and reflect on their relevance to the theme of Safety and Society. The two articles are:

1. Pidgeon, N., Harthorn, B., & Satterfield, T. (2009). Nanotech: Good or Bad? The Chemical Engineer, 822(3), p. 37-39.
2. Grimston, M. (2007). Back on the agenda: The curious case of nuclear energy and public acceptance. The Chemical Engineer, 796, p.27-29.

The reflective blog invited responses from participants to address:

1. What are the most important issues that emerge from the article? Based on your reading, how is this article relevant to your understanding of risk management?
2. How does the 'Ford Pinto' case study relate to your article topic?
3. Have there been incidences in your life when your perception of a particular technology has hindered your acceptance and subsequent use of it? Can you describe this experience? What did you do to overcome your personal reservations about this issue?

Reflective Blog Exercise 2 (Home Activity for Week 6, Online Submission)

An article from the IChemE's "Loss Prevention Bulletin" has been provided. Students were asked to reflect on its relevance to the 'Safety and Ethics' theme discussed at the workshop. The article is:

1. Brian, Harris. 2004. "Directors' and Engineers' responsibilities for Safety – a Cautionary Tale." *Loss Prevention Bulletin* (180): 12.

The following questions will need to be addressed in the reflective journal/blog:

1. Discuss the various ethical considerations implicated in this case?
2. Using a systemic point of view, explain why being ethical in our conduct is important in our everyday personal, social and professional life?

Reflective Blog Exercise 3 (Home Activity for Week 9, Online Submission)

Demonstrate, in your own words, how you employed systemic thinking to conceptualise the notion of "safety culture" through the workshop activity. You are free to use additional media and information sources (journal articles, magazine articles, web-based information etc.) to persuade the reader so long as citations and references are provided and used correctly. Your objective is to construct a unique and personal response through your writing. Each blogger ought to be able to highlight how one's own approach and experience of the workshop activity has provided one with a particular point of view.

Appendix 5.   Dell's Reflective Blog Response in Week 6

The author Brian Harris talks of his experiences as Joint Managing Director of Nobels Explosives Company Limited and has a particular focus on an incident that resulted in the deaths of two employees. It is apparent from his description that he believed he took due diligent care in the operations and occupational health and safety that he was responsible for. To more easily clarify what occurred and provide an opinion on his experiences it would be good to have a short list of what transpired during the incident

1. There was an explosion at one of the mixing houses
2. Two employees were killed during the explosion
3. The two employees had breached procedure by being outside during the mixing process instead of in the reinforced bunker
4. Other employees were aware that the two dead operators routinely breached procedure

The author mentions that he felt he had fostered a good relationship with the employees and management at the factory and that there was a "family" type of culture apparent. It is perhaps here that an ethical dilemma occurred. Although such a culture is good to foster effective working relationships between individuals, there is the risk that the culture goes to far and impinges on good sense.

The fact that two employees were able to routinely breach procedure by being outside during a mixing cycle points to a negligent attitude from the factory management. This could have perhaps have occurred due to the close knit working relationship allowing seemingly minor breaches of procedure to go unchallenged. The managing director is this case would have had an ethical responsibility to make sure the factory management did not let their interpersonal relationships interfere with proper procedure.

Given the incident that occurred it surprises me that the factory management were not individually charged with criminal negligence or manslaughter due to their unwillingness to enforce proper procedure. The heirachy of the organisation seemed to show that the managing director (author) was responsible for producing effective working procedures and the factory management were responsible for enforcing them. In this light the author did indeed fulfill his ethical obligations to provide a safe working environment but perhaps failed to ensure they were properly carried out.

Given that the author visited the site four times a year and there were area audits, it surprises me that he was not made aware of the common breach of procedure that was occurring. This also leads me to suspect the existence of an "old boys club" within the factory working environment, especially considering the breach of procedure was documented in the log books and so should have been readily apparent to an inspector.

The reaction to the incident involved the informing of the bereaved families, working with forensic teams and police and dealing with the remaining explosive that could self ignite in 10-14 days. Informing the families as soon as possible was an ethical thing to do as well as allowing forensic teams to work unimpeded. Having two employees hand carry the remaining mixture to storage in runner buckets seems ethically unsound given the explosive nature of the material, especially as it was done in order to preserve production rather than save lives. However there is no description as to how inert the material was at that stage in the cycle and so it could be that the operation was quite safe if the product could not chemically ignite at that stage in the process.

In total it appears to me that while the author behaved ethically in regards to writing procedures and handling the incident (except perhaps the employess with the buckets mentioned above), it seems he may not have had sufficient oversight over the management of the factory. If he had investigated further during his visits and audits he may have uncovered the breach of procedure and been able to prevent the loss of life. Instead he seemed to believe in the good working relationship he had with the management and was perhaps too trusting as a result. An ethical point that can be gained from this is that even with a good working relationship there is a responsibility to make personally sure everything is being followed correctly.

Ethical thinking is important to our everyday personal, social and professional life for several reasons

1. In encourages an altruistic culture, as if you behave ethically towards others they are likely to do the same in return. In this way all people gain the protection of others and incidents can be averted.
2. Ethical behavior builds trust within social groups. In this way people can enjoy their lives and the company of others without having to feel they have to guard themselves.
3. In professional circles ethical behavior allows greater cooperation and hence an increased productivity of both individuals and the company as a whole.

4. For our personal lives, it allows a feeling of greater fulfillment (unless sociopathic) that provides a more rewarding lifestyle.

Appendix 6.   Noam's Reflective Blog Response in Week 6

The paradigms and inconsistencies associated with ethics/ethical behaviour: What should we do?

Just when I thought that the subject of philosophy could never be challenged for its place as the most vague and uncertain of all learning's, along came ethics. Yes, perhaps a little critical for an opening statement, but let me explain my frustration (and in turn that of many others on both sides if the fence). I was first introduced to ethics during post graduate studies in business.

The semester long course introduced us to not just the various definitions of what ethics and ethical behaviour might be, but also to the various ethical theories which might be employed in order to analyse or support behaviours/decisions. These ethical theories ranged from 'Cognitivism and non-cognitivism, Religious morality, Consequentialism vs. non-consequentialism, Utilitarianism to Kantianism and Natural law'.

All of which may be employed as a position from which to argue your stance, hence my comment referring to inconsistency and uncertainty. However, all is not lost. As with all good engineering practice, let's start with a static definition: "Ethics is commonly defined as a set of principles prescribing a behaviour code that explains what is good and right or bad and wrong; it may even outline moral duty and obligations generally." (Henderson, V. in *Business Ethics* 1993:51)

This seems simple enough, however because of the very dynamic environments in which we all live, this definition is clearly too vague to be useful and so it's back to where we started. This is because it presumes that everyone agrees and adheres to not just the same ethical principles, but also to the same level of ethics, which is not the case in today's pluralistic society.

These diverse views found in our society are attributed to changes over time in our different environments (social, religious, corporate etc.), such as   shifts in cultural values, creation of conflicting interest groups, demise of Puritan based ethics as well as the ever increasing tendency to use legal criteria as a basis for ethical decision making.

This is clearly illustrated in the article by Brian Harris where he voices his discontent with the decision by the company to plead guilty and pay the fine. Brian and his colleague, as the MDs, were certain that they had been diligent and ethical in their (and by extension

their companies) behaviours, but the company for which they worked believed otherwise (for legal reasons).

His frustration was born out of the fact that he believed that he had high ethical values with respect to the safety of his employees and this was illustrated in the way in which he personally prioritised safety and the degree to which he took a special interest in it. He assumed that everyone beneath him also prescribed to same level of honesty, integrity, responsibility, respect for the rule of law, care for other people's wellbeing/safety and that they demanded the same level of accuracy and rigour in their assessments.

As can be seen from the outcome of the enquiry, this is not the case. The employees that were killed by the explosion did not have the same ethical viewpoints or understanding as their management and so were willing to take risks by cutting corners (not following procedures) in order to satisfy their need for more time in the canteen. The management within the company did not pick up this behaviour (not rigorous enough), nor did they act upon it (respect for life/public good), again because of differing ethical viewpoint's/understanding.

Another ethical dilemma occurred when the remaining batch of nitro-glycerine was removed by hand instead of the batch being destroyed through detonation, as was recommended by the HSE advisors. The HSE advisors wanted the option with the least risk to personnel, but the company did not want to endure further destruction and commercial loss. More lives were put at risk because of the decision.

This is a good place to highlight the fact that because of the differing degrees of ethical behaviours that are found in both our personal, social and professional lives, we must always strive to create and promote adherence to a robust and adequate set of ethical guidelines/principles (as can be found in *Statement of ethical principles* by Royal Academy of Engineering) in our professional lives as well as in our personal lives (Puritan type ethics or similar ethical philosophies).

The primary reason that I say this is because we should all strive not to impose, but to convince people, societies, groups and organisations with whom we interact that by subscribing to an agreed set of ethical principles, we are assuring a degree of parity in the decision making influences of the aforementioned. This is of paramount importance because clearly every individual decision/ethical behaviours of one will affect many.

Appendix 7. Carrie's Reflective Blog Response in Week 6

A number of ethical considerations are considered in the article "Directors' and Engineers' responsibilities for Safety – a Cautionary Tale" (B.Harris. 2004, *Loss Prevention Bulletin* (180): 12). This includes considerations of to whom blame should be attributed and at what point one must accept the responsibility of others. Ultimately the article raises a number of difficult ethical considerations which recognize the delicate balance between individuality autonomy and directors control of corporate actions.

It is critical that the ethical questions surrounding the two people who died are considered first. The plight of these two individuals raises a number of questions. Personally I keep asking myself why didn't they seem to care as to what the owed there employers? It raises question in my own life – how would I respond if I was in their situation? In my casual job at a nursing home, I admit to sometimes 'cutting corners'; however the critical difference is that I can recognize the difference between cutting corners to save time (e.g. making one big pot of tea rather than everyone getting an individual cup), and cutting corners which impose potential significant risks to both myself and other such as not correctly sterilising cutlery.

It makes me recognize that a critical part of ethics is personal integrity; while the company does have significant control as to the wider processes and procedures that must be followed, there is always a point where individual actions, such as 'cutting corners' threaten the integrity of those procedures.

Particularly in Australia where we are notoriously laid back, it is critical for the safety of ourselves and others that personal ethical integrity in the workplace is encouraged by the processes and procedures set by company and also fostered as part of a larger working cultures.

This sentiment is echoed by B. Harris in the article. In his review of the company, he states, you should be fulfilling your role within in the company to your best potential, as to increase the probability that the people in your organization will not be injured, and that you can return home to your families.

As such it is recognize the capacity for both company and personal gain, such as returning to your family at night, that maximizes safety in the workplace and indeed is the best assurance that workplace procedures regarding safety are fostered. I do however note that work in aged care, while working with vulnerable people, is less

"hardcore" than working at an explosives plant and it would interesting to see whether this lower degree of risk perceived would mean that people take greater risks than in an explosive factory.

Irrespective of the industry, it is critical that all employees should be encouraged to exceed safety standards set by companies and aim to go home their families at the end of the day. So again, tieing into the notion of cutting corners, it is important to note the difference between 'cutting corners' and being negligent; while I make tea by the bulk so I can sit down and talk to my favourite residents for an extra 5 minutes here or there; this is still part of my job; moreover I am present in my location.

As such I can see the pertinent difference between valuing the canteen social scene; rather than being on location, with residents. As an employee at the nursing home, I personally aim for myself to make as many residents smile as I can in one shift, whilst fulfilling my job requirements. If I can manage this while ensuring the safety of myself, my co-workers and residents, then I have met my own expectations, and my obligation to the company.

I think from taking a step back from Harris's article the general guidelines for employers must be considered. HSE (the executive body intentioned in Harris's article) published on its website some remarks in relation to ethical considerations for companies including the question: What is it that we owe our employees, customers, shareholders and the community at large, and how does our fulfillment of these obligations ensure our long-term sustainability as a company?

This is followed by the statement that Professional Engineers work to enhance the welfare, health and safety of all whilst paying due regard to the environment and the sustainability of resources. Both bodies have made personal and professional commitments to enhance the wellbeing of society through the exploitation of knowledge and the management of creative teams.

It is interesting to consider these points of view in terms of considering this from the viewpoint of the executive body, and indeed from the company organization tree from CEO right down to operators. Harris noted that he was relieved it was a company court case, rather than him personally, is an interesting point: if he was doing his job to the best standard he can, what does the company owe him in regards to support?

Moreover, despite Harris being the managing directors, it is important to note the balance between his responsibilities and the personal autonomy of his employees to choose not to follow the relevant procedures. I found Harris's exploration of his personal story reconciling his corporate and legal responsibilities in reality, and furthermore reinforcing the harsh reality that our failure to meet all the requirements, all the time may result in severe corporate and personal penalties through ultimate judgment before the court. The balance between corporate responsibility and personal autonomy is difficult to reconcile and raises and number of ethical considerations.

Ethics in relation to company practices should start with corporate-social responsibility. I think with any job it is critical to consider the balance between a companies own interests and their interests as an employer. Working at a nursing home, I cannot think of a better example than the manual handling policy which I must follow at work. The companies manual handling policy states that attempting to " catch" a resident as they fall is considered serious misconduct.

This shows the company does not want us as employers sueing them for back injuries (as serious misconduct is legally considered a sackable offence). However as an employee in a care-giving industry, it is natural instinct for me to help a resident as I am young, and fit and able, and can withstand more than they can. I cannot help but think how does this policy show the companies fulfilment in support for me as a worker?

Ethical considerations in decision making affects everyone. The Royal academy of engineering states that the ethical principles one must uphold include; accuracy and rigor, honesty and integrity, respect for life, law and public good, and responsible leadership. As ethics is a moral philosophy upheld by everyone I think it is safe to say these principles should be exceeded by every individual in society as to show how being ethical in our conduct is important in our everyday personal, social and professional life.

I think as a student engineer it is important for me to read these case studies as to realism the harsh reality of failing to fulfil the stringent safety requirements that exist in practice. To be honest, in reading the first few pages of Harris's article his attitude within the company and to differing levels of employees seemed commendable; the safety protocol and communication upheld at the company seemed great. This is why reading this further hits home that ethics must always be at the forefront when making decisions, as disaster can strike at any time.

Appendix 8. Ken's Reflective Blog Response in Week 6

<u>Article Utilised:</u> Brian Harris. 2004. "Directors' and Engineers' responsibilities for Safety – a Cautionary Tale." *Loss Prevention Bulletin* (180):12.

1. Various ethical considerations of this case: Brian Harris has indicated that he along with ICI did have significant and seemingly comprehensive ethical measures in place - especially in relation to Occupational Safety and Health (OSH) and the Environment (ENV). These ethical measures were in place at the time of the accident that killed two employees on 14 June 1988. For example, the ICI Group had a strong focus on OSH and ENV that not only included the "paper-work" eg policies but also included "actions" eg:

   - Visible commitment to OSH by senior executives (my view (mv) - encourages others to act safely and ethically – likely positive effect on People, Plant and Procedures);

   - Directors investing large amounts of time to foster good communication throughout the company (mv- increases systemic interaction and likely to increase awareness and knowledge of OSH, ENV and thereby encourage more ethical behaviour);

   - Weekly toolbox meetings including OSH (mv- increases systemic interplays between workers with same and different roles and with supervisor(s) – eg opportunity to explore issues (including similarities and differences) of Plant; Procedures and People) – another interpretation - encourages ethical discussion on a potentially systemic plane.

Focusing more on the accident, it raises in my mind a number of ethical considerations:

It appears that the operators were killed during the mixing stage because they were outside the reinforced control room – which survived the blast(s). There was also an extra 250kg batch of nitroglycerine still in the mixing house at this time.

Being outside the control room whilst mixing is occurring and leaving an extra batch in the mixing house was (i) against or not in accordance with specific safety procedures (ii)

this behaviour may have occurred fairly regularly for some time (refer page 8 "causes – It was well known…"). It is suggested that the operators did these "process short-cut" behaviours to have more of their own time eg time in the canteen.

Point (ii) just above brings in ethical considerations relating to (a) the killed workers themselves (b) their colleagues and (c) management – the Company.

Within this discussion I will identify the following three <u>Risk</u> Player <u>Roles</u>:

1R Those are potentially exposed to the risk

2R Those who make decisions that affect the risk

    3R Those who gain from the risk being taken

(a) certainly with hindsight, if the killed workers had a sense of the real risk they may not have taken the indicated short-cuts - if a mixer worker still carried on with consistent breaking of significant safety procedures with real awareness of the risks then he or she would certainly put themselves and their colleague and anyone else in or near the mixing house at serious risk directly and indirectly by displaying behaviour that is against safety procedures, their ethics could be classed as questionable. <u>Risk Roles</u> clearly 1R, 2R and 3R (extra "free or canteen time");

(b) it is indicated that work colleagues knew about the short-cuts; if this is the case, then one wonders what action was taken by them (if any) to correct the non compliance with significant safety procedures. Again the ethics of doing nothing in this regard would be questionable. <u>Risk Roles</u> 1R – particularly if near the mixing house; 2R – colleagues seemed to have had the potential to both "casually" and "officially" try to correct the non-compliant behaviour; 3R – perhaps if not confronting the issue had advantages eg smoother work and personal relationships, perhaps

other areas were also taking short-cuts which would also have been affected?

(c) if this short-cut behaviour was regular, then the supervisors and managers should have been aware of this non-compliant behaviour and acted to correct it and also increased their supervision / monitoring of work procedures – also brings ethics into question. <u>Risk Roles</u> 1R – directly if near plant also exposed to media, litigation etc; 2R – can increase compliance and auditing

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In regards to the after explosion stage where there was still question marks about the cause – the production was halted - this appears to be a strong ethical approach as it guards against the possibility of a repeat explosion during manufacture; however the removal of nitroglycerine from the other mixing house was a difficult decision for a number of reasons. It appears that it was an ethical dilemma for a while.

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2. As can be seen in examples such as the above, being ethical in matters or events that can have direct serious consequences on the lives, health and well-being of yourself or/& others is critical to not only helping to directly prevent serious adverse affects on you or others (or the environment) but also indirectly though "setting an example" or "encouraging positive ethical behaviour".

Whilst it may be more obvious to behave ethically in a professional or job role, in reality, the matters or events referred to above may occur or be influenced by ethical behaviour in any aspect of life whether everyday personal, social or professional.

Appendix 9. Freya's Reflective Blog Response in Week 6

The article "Directors' and Engineers' responsibilities for Safety-a Cautionary Tale" addresses the background, consequences and lessons learnt from an explosion at a nitro-glycerine manufacturing factory in Wales in 1988. It is written from the point of view of the author, Brian Harris, who was the managing director at the time of the explosion. His insights into this case study, though in some cases specific, relate to the "safety and ethics" that many engineers in a position of responsibility would need to consider every day or especially after a disaster.

For me personally, the lesson described by Harris that seems the most relevant to this case study, and is something that I hadn't considered in the past is: "How do you know that what is supposed to happen does happen? Too many assurance processes check hardware and systems and fail to assure what people actually do. How do you know that the procedures throughout your organization are being followed?" Cookes Works, the company who owned and ran the factory, seemed to have all the right safety procedures and policies in place.

The design and layout of the factory and other buildings minimised the likelihood of any explosion, and also the size of the incident if it did happen. There was a good system of safety and hazard review and a good relationship between managers and operators-at least from Harris' point of view. However, two operators failed to follow procedure and were negligent. But they paid for this with their lives. If they were more closely supervised, perhaps the disaster, or at least their deaths, could have been prevented.

Harris also mentions that other operators and workers knew about the "cutting-corners" behaviour of the two operators, yet they didn't feel the need to bring the issue up with them or anyone in charge. Why didn't they speak up? The behaviour wasn't one time thing, and ongoing evidence in the logbook of them not following procedure, but no one felt like they had to do something about it. People were complacent about the breach of safety procedure, and it led to a disaster and two deaths.

And why did the two operators feel it was ok to not follow the procedure? Were they not aware of the consequences? I know that sometimes people are told to do something and are told it's for the best, or their own good. But there is a lack of understanding of the actual consequences. Or they didn't think that anything could ever happen to them.

So there was complacency on behalf of a number of people, and unethically, people weren't looking out for each other.

Harris doesn't blame himself as a managing director for the lack of supervision, but does take responsibility. He was told by the parent company that in the legal proceedings after the event, his first priority was to look after himself. But at all times he was aware of his corporate responsible. He doesn't blame anyone else either. Ethically, this can be considered as the right thing to do (not pointing the finger), and considering that he was under investigation by the HSE and the police, it shows the complexity of ethical issues that directors (and engineers) face.

This case study shows that though the company was doing all the right things ethically for the safety of the people. However, the workers didn't look out for each other, or didn't take the responsibility of speaking up about an issue, which isn't the ethical thing to do. I think this is especially so for engineers as they have the ethically responsibility to aspire to high standards of leadership, and hold privileged and trusted position.

In everyday life, not only at work, but everywhere, it is important to conduct myself ethically. I'm interacting with people and the environment every day, and if one day I decide to do something unethical, I can damage the environment, or impede someone else's way of life, or upset their day. I don't have the right to do that. In everyone's personal, social and professional life they are interacting with people and the environment and if someone decides to act unethically then this can have major consequences.

Sometimes the unethically conduct can also have ripple effects. People's families could be affected by a boss unethically dismissing an employee. Or dumping waste incorrectly, but perhaps not illegally may not have immediate detrimental effects on the environment, but after heavy rain or decomposition, maybe then it will have an effect or may wash into waterways that go through natural parks. It is so hard to know the full effects or our actions, that why it is so important to conduct ourselves ethically in all areas of our lives.

Appendix 10. Chuck's Reflective Blog Response in Week 6

After reading the article by Brian Harris I found myself always going back to one facet of the description which was the decision made by the court. It was up to the court to decide whether the individual (Harris) or the company was guilty. I guess looking from a biased perspective in the blog, it was lucky that he himself was not fined and let go, but charging the company had many other unseen effects like commercial impact and a much higher insurance premium.

This court decision comes down to the ethical consideration of who was at fault here. I personally believe that the two men were at fault for their accident because they willingly chose to disregard plant procedures for more time in the mess. I don't believe that any director or company should be fined or charged for two individuals' personal choices to disregard HS&E put in place for their own benefit.

At the same time I realise that when something like this happens, the public and everyone else who is outraged want someone to blame and to take up the responsibility for what happened. It angers me that these two not only risked their lives, but possibly others too, if by some freak accident the other storage facility blew and there were others nearby.

Consequently it becomes the company's responsibility in not ensuring that the workers were following the procedures correctly, and this was found by the court. It does become a matter of due diligence when these men were cutting corners for as long as they were – someone should have noticed.

Hence the incident becomes tangled in a web of responsibilities - those of the workers to stick to the procedures, that of the supervisor and plant manager to ensure that the workers stick to the procedures in place, and that of the director to ensure that the managers below him are on top of their workers with following safe and correct procedures. Inevitably, as the director, Harris was not omniscient or omnipresent which was obvious from the fact that he did only go on four site visits a year.

Having said that, we all have an ethical responsibility in our personal, professional and social lives and an obligation to act ethically. Why? So we can earn our right to live in a safe, considerate and secure society, knowing that others are (hopefully) making ethical decisions for the good of everyone. As airy fairy as it sounds, it makes perfect logical

sense. If I were to drive drunk down Canning Highway, it would be my own choice. BUT it wouldn't be the choice of other drivers to be put at immediate danger of my risky driving.

Neither was it their families who'd potentially lose a son or wife or daughter, or the City of South Perth's, were I to damage public property while losing control of my vehicle. It is a personal responsibility which extends to a wider social responsibility, hence why your friends or authorities prevent you from getting in the car. Not to mention, loss of income for my family (if I have one dependent on me), grief, sense of loss and similar ripple effects. The connections we have to people and society become infused with a moral or ethical responsibility to do what is right, not just for ourselves but for the sake of greater society as well.

As I've had work experience with an engineering company, I have been exposed to ethical professional practice. The company I worked for has a technical engineering contract with Chevron for the oilfields on Barrow Island. As Barrow Island is a Class A nature reserve, the care taken for environmental impact is always a high priority. There is a desire in all engineering work to not only comply to standards but give a reasonably, slightly over-conservative consideration in order to go above and beyond the environmental precautions already in place. All of us knew that it was a delicate system and this was reinforced in the Chevron online induction as well, thus we felt ethically obliged to follow correct procedures and responsible for the safety of people and the environment on the island.

I believe that after considering the article by Harris and then looking at a more non-specific example, that I have grasped a better understanding of ethics in society and its relation to safety. Systemic thinking is key to thinking safer and more ethically, as it encourages you to consider more perspectives than just your own, and provides a more rigorous method for fleshing out safety issues and more specifically, ethical issues which occur as a result of a breach of safe practice. Keep it safe, keep it cool.

Appendix 11. Question Guide and Semi-structured Group Interview Schedule

Primary Question: We've all had an experience of what systemic thinking might be. What do you think it is?

Alternative Primary Question: Now in hindsight, how would you define your understanding of systemic thinking? What would it mean?

Primary Question: What did you perceive the unit was telling you about thinking systemically?

Alternative Primary Question: If you were to apply systemic thinking, what would be your approach? What would you do?

Alternative Primary Question: What would be your approach towards applying systemic thinking? If you took an example for yourself, and you worked out on it, what would you do?

Primary Question: What did you gather to be the take-home message about systemic thinking? What would you consider to be essential?

Primary Question: The workshops that we had for thinking systemically, what was your take on them?

Alternative Primary Question: What was the benefit of those workshops activities for you personally?

Primary Questions to Promote Discussion:

Do you think systemic thinking is an individual thing or would you prefer that it becomes more effective as a group activity?

Do you suppose that this way of looking at things systemically is applicable for pretty much everything or certain things more than others?

Do you see any use for systemic thinking as a skill or as an approach to thinking? Why should it be worthy of attention?

Why do you think systemic thinking is hard?

What do you think we would use systemic thinking for, as against any other type of thinking?

Appendix 12. Transcript of Group Interview 1 held on 6 June 2012

This document contains selected snippets from the transcript of the Group Interview Meeting 1 with 6 student participants. The Group Interview Meeting 1 was held on 6 June 2012.

Interviewer (research investigator)'s questions and statements are presented in bold black font type

Pseudonyms for Participants: Yul, Chuck, Neil, Rocco, Leah, Carl

Leah was unable to attend the start of the discussion. After about the first 30-35 minutes of the discussion, she joined in.

Carl chose to attend. However, he chose not to share his views during the discussions. Instead, he would actively nod in agreement on many of the points raised. At the close of the discussion, I asked him if he wanted to add anything further in person. He smiled and responded by saying that he didn't have anything to add, but he was glad to have attended the session.

Snippet 1

Question: We've all had an experience of what systemic thinking might be. What do you think it is?

Yul Responds:

Well it was a bit confusing to start it, but I sort of…myself (.) when I think of how do I go about thinking sustainab(systemically) I don't have a very complicated or difficult explanation…I pretty much (.) in my head go…think about everything and just seems to work for me. Think about everything…your model…people, plant, environment, or something like that…think of everything and anything that could go wrong, coz that's what we are trying to stop essentially if you're going to stop things going wrong. So (.) in my head going…think about everything is enough for me to drive through and get it done.

Neil Responds:

I reckon that to me it's a way of thinking holistically, I guess. There is also like certain…I found that I needed to get hold of certain words or triggers that could help me think

holistically. Just thinking holistically, because it's thinking of everything you know you're gonna miss out some things. People, Plant, Environment, then you're able to categorise things and your thinking…just people…because it's a category… then you can list more things, or take into account more things. And then once you go…people, plant, environment, then you can think of all other external factors from there as well out of the process side of things. ((See also Neil's response in Snippet 9 regarding difficulty in thinking systemically. This ties in to Rocco's response below about what he finds hard))

Rocco Responds:

We know that we have to think about everything that is linked to a certain topic but what I found is it's hard to categorise it. Like people, plant, and environment, when I came with an issue I find it that I'm not sure if I categorise it under people or under environment because it is somehow interrelated., which is what systemic thinking is about…it's not about categorising everything because everything is related to each other…it has to be mentioned or considered instead that oh I need to find something that is related to people that is affecting the environment or the plant. But more on specific topic that is linked to all three.

Question: Did you guys find a similar experience of difficulty in classifying or categorising?

Neil Responds:

Yeah. Definitely. It kind of works and does not work. If you find you can't categorise, then you it almost links in a line cause and effect instead of categories. It depends on how stressful it is.

Chuck Responds:

In my head I sort of see it like a web…one thing to another…all interconnected… go everywhere.

Snippet 2

Question: Anything else about systemic thinking?

Chuck Responds:

I found going into this after vacation work is really useful. Because obviously modern Australian companies you get a lot of…the safety culture. I didn't realise how pervasive it was throughout the company, and intercompany relations, and down to the employee level and how much everyone talked about it, how it was reinforced….safety first, safety first…and like the environment. I went to Clough, and they had their program Target Zero…Zero harm to people, environment, and community.

Neil Responds:

Exactly the same in Worley Parsons.

Chuck Responds:

And you think like, aww yeah that's cool, they have to have that. But you don't realise that sort of…I guess the workshops helped discuss why they have it, the selfish and unselfish reasons…and that they want to protect their reputation, have a good reputation, but also because they have to protect the environment and that.

Question: So when you are doing it in the industry, you don't really know what the context is…this is it, this is their priority.

Chuck Responds:

It's sort of like you're a baby, like you're teaching a baby, this is how you do it…just do this, this is how you walk. You don't really know, just stumbling along.

Neil Responds:

This unit has helped us get a different (.) perspective…where we're not in a company…we don't get directly affected by it, almost a neutral perspective…to take everything in, whereas if we were a ceo we'd get defensive learning or speaking about something or subconsciously refuse to learn something.

That's a good point I think you've raised about learning something or the need to learn. In my understanding there is a difference in the way one would learn in the industry as against learning here in the classroom. What sort of difference do you see based on your experience?

Neil Responds:

Yeah, very different!

Chuck Responds:

It's a different focus….obviously when we come into the class we have one aim to learn about that. While in the workforce it's like they tell you, but you're there to work for them. They assume you know it, it's a part of the company culture; it's not really talked about that much. In the class it's more focused.

Yul Responds:

In class you don't have the workforce pressure to get things done; there's no production targets to meet, that stuff is not an issue. Whereas out there…we want to make money, that's why we are all here, that's why we are getting paid. More money, more bonuses. You don't have that financial incentive in the classroom.

Question: Do you suppose that that sort of pressure affects learning then?

Chuck Responds:

Yeah

Neil Responds:

Yeah it does.

Yul Responds:

It provides people with a more positive attitude toward safety culture. Whereas when I started working in the labour force, you wanna get it done but we want you to get it done safely. But they'd snap turn around and say …we want you to get it done in time…and we're like well if you rush we're not doing it safely…which one…nah nah…we want you to get it done safely…but we want you to meet the production targets. In the classroom it's not like that, no tit for tat…it's all just there it is.

Neil Responds:

The good thing about classroom (.) the culture of learning does not clash with any other cultures. Whereas productivity always clashes, always clashes with safety culture. Or if you can't learn it, you just can't.

Statement: It appears that what you learn of safety culture in the industry is almost subtle, coming from experience. Like osmosis exchanging nutrients from the environment. But in the classroom we have made it a focus and invest in it.

Chuck Responds:

I feel I went into it a bit blind really (referring to industry experience of safety culture).

Rocco Responds:

They (referring to industry) expect you to know already.

Chuck and Neil synchronously Respond: Yeah.

Rocco Responds:

But here you look at us and say we do not know everything. You're actually trying to teach us.

Chuck and Neil synchronously Respond: Yeah.

Chuck Responds:

I'm not sure if it would be better to do this unit before or after vacation work. Vacation work exposed me to a lot of things I didn't realise.

Neil Responds:

Yeah

Statement: I think I like the idea of experiencing first and then trying to understand it later, it puts things in perspective. That's what I noticed in your blogs, the fact that so many of you were reflecting on your work experience visible. It was one of the most tangible things.

Chuck Responds:

And you didn't even prompt it or anything…it's what we've thought about.

Neil Responds:

Yeah

Statement: And that's good because it contextualises what you're learning. As you said earlier, you go in there (referring to industry) you go in cold really, and when you come into the classroom and there is no pressure, you're free to make connections.

Chuck Responds:

I think it's better to do vacation work first then this (referring to risk management unit). It's also like a motivation and driver. With vacation work you get paid for this, it's a driver for why you want to do it. I mean, you obviously want to do it for the experience but you (.) it (.) it's like motivation. It is extra motivation to get you doing it properly. Doing vacation work first and then doing RM is a driver to understanding RM better. Otherwise it would be an airy-fairy thing; you don't know what it means, where it fits.

Rocco Responds:

I think it applies to all other units as well.

Neil and Yul Respond in unison: Yeah

Snippet 3

At 30:56

Question: What did you perceive the unit was telling you about thinking systemically? Did it give you the framework you were looking for, to contextualise something as vast as that?

Neil Responds:

I think it is cool we started out small. If we had started off with the last week's exercise first it would have fried our brain…Good intention. Good direction.

Yul Responds:

Easing into it.

Question: What sort of take-home message about thinking systemically would you take? What would you consider to be essential?

Yul Responds:

Try and look at everything as unbiasedly as possible to do an accurate analysis.

Rocco Responds:

I agree with him.

If you'd give us week 12 exercise in week 1, we'd still develop our thinking. But I think week 12 is still tougher because we understand how it works. In week 1 we'd think it's more on the technical side instead of thinking of the whole system. So I think in terms of assignments and projects we were given it's not going to make any difference how you order it. It's more on how you develop your thinking. In the concept map our links kept increasing because we were developing our thinking. The concept map was the same every time –

Chuck and Neil Respond in unison: Yeah

Rocco continues: - But it's just that our thinking changed, so I think that's the key point. ((See also Rocco's response in Snippet 4 regarding perception of growth in thinking expansively and inclusively as the weeks progressed.))

Question: So you could notice that change across the unit not just the concept maps?

Chuck and Neil Respond in unison: Yeah. Yup

Rocco Responds: It became much easier to do each task because our thinking expanded but it also means it required more work [yeah?] [yeah coz its…to contain all the ideas and stuff]

Snippet 4

Question: In terms of the weekly activities how were they affecting your learning of the unit?

Neil Responds:

It made us learn, for me personally.

Question: So it actually coaxed you…?

Neil, Chuck, Yul Respond together: Yeah

Neil continues:

Definitely anything where you have to do stuff in class…do activities in classes are immediately better than a lecture. [Yeah] [Hmm].

Yul Responds:

Discussions were very valuable.

Rocco Responds:

It's also a good indication that we can actually see how we improve as well.

Question: Did you? Actually, in the discussion itself you could make out for yourself?

Rocco Responds:

Yeah, comparing to week one to week 12 you can actually see you improve over the semester.

Question: What sort of experience did you have?

Rocco Responds:

Because, I feel that like I said earlier. In week one it's more like answering what the question actually wants. But as the week go on you start thinking it's not just a question, the question is just a starting point. And then you start considering other things that are related to this topic…Week one you can write actually a two page answer or solution. But in week twelve you are tempted…tempted to write twelve to thirteen page because you actually can write! Because a lot of things are related to… But we try to constrain…reduce the amount of work by saying to yourself that since Nicoleta said you have to do it in one hour only that's as much as you're going to put it. And not consider more. If we were given unlimited amount of time, I think, a lot of us would hand in actual report as a solution because you can write a lot. I believe that we actually show you that we are improving comparing to week one.

Snippet 5

Question: What do you think is useful about thinking systemically? Why do you think it's valued as a skill?

Yul Responds:

Well, it's not just for Risk Management ((soft tone but emphatic)).

Statement: No, certainly not just for Risk Management ((in agreement))].

Yul Responds:

Yeah.

Chuck Responds:

It just sort of (.) provides a different way, different structure, different perspective to see (.) the world you live in, I guess; and, how you can use that in different ways in engineering, and in life.

Snippet 6

Question: The workshops that we had for thinking systemically, what was your take on that? How useful were they in helping you learn about the other things that we were doing in the unit? Did you see a connection?

Chuck Responds:

Yeah, definitely. They gave another sort of platform and area to discuss and to learn more about the things we were already learning about but in a more…in a less focused way, in a less specific way, and more like…let's deal with larger ideas and broader.

Neil Responds:

Yeah, it was open discussion.

Chuck Responds:

Yeah it was a bit more conducive to that sort of learning, although, they were a little bit isolated. But, I guess that's the nature of the –

Question: In what way?

Chuck Responds:

Because they were so far apart and there were just three of them. A little bit isolated in that sort of respect.

Question: So what would you suggest we could do instead?

Chuck Responds:

I don't know. I didn't think that far ahead. That's just what came to my mind.

Leah Responds:

I would…I would think that the presentations we were doing in each lecture…replace those with discussions. I would almost say if you do that each time, like every week that's going to have a bigger impact than doing presentations.

Chuck Responds:

And maybe have only group present each time.

Yul Responds:

You don't need to hear the same thing six times.

Neil and Chuck together Respond: Yeah.

Rocco Responds: It's not necessary.

Question: So you felt there wasn't any new information you were gaining as a result of that experience.

Yul Responds:

A few different things came out, that's for sure. But if one group presents and then you can have a big discussion -

All present respond in unison: Yeah ((distinctive multivocal concurrence))

Yul continues:

That'll knock out eighty percent of the stuff that people are thinking about

Chuck Responds: And if you happen to be the last group to present then you have all these other ideas.

Rocco Responds: Yeah

Leah Responds:

If you have presentations every week you lose the point of it.

Neil Responds: Yeah

Leah continues: You sort of think…oh…I'm just doing this for the sake of presenting as opposed to actual point of it…which is supposed to be getting out key information from whatever it is that you're summarising.

Question: What was your experience of the feedback you were receiving from the presentations? About being critical and that sort of stuff, did that come across to you?

Leah Responds:

Nah.

Rocco Responds:

Not really useful. But I would like to say…in terms of the learning aspect…presentation is actually not quite useful enough

Neil Responds:

Yeah

Rocco continues:

But I think in terms of a skill as an engineer I think it's really important.

Chuck Responds: Yeah.

Rocco continues:

The first part of the presentation is more useful than the second. We had to do the in class work and then present it. While in the second part of the semester, what we reflect on our homework and then present on it. A lot of my cousins are chemical engineers and what they say that…a lot of management expect you to present…prepare a presentation one day before hand because they don't give you a project one month ahead and say…oh…one month later you have to present. We need you to present tomorrow, present our ideas or solutions straight away, and I believe it is a useful skill. It

teaches us that we have to think as quick as possible and to know where we get our resources to actually present. [Yeah].

Chuck Responds:

Well…to reinforce presentation skills…because that's more important than any other [Yeah] things we didn't have a choice. I had to, and Neil ((Chuck points to and refers to Neil)) had to as well ((Neil nods in confirmation)), present at the end of my vacation work and we actually had like a presentation workshop which they conducted for us, and that was really good…to go back and practice something I had learned and gone in coldly and then (.) reinforced that sort of thing.

Question: So you're saying reposition the idea of presentations. They are good, let us have them but not as many of them? Like a summative thing at the end of the semester?

Chuck Responds:

Yeah

Statement: So there is perceived value in the actual discussions preceding the presentations, but the presentations started becoming stale.

Leah Responds: Yeah. Maybe have less presentations, but still have presentations

Chuck Responds:

Yeah

Leah continues:

Because not a lot of units have presentations, and I think it's very useful as an engineer.

((A break commences after this statement, refreshments have been made available to all participants)). 57:06

Snippet 7

At 1:03:37

Question: Did you find the blogs relevant to our need to develop systemic thinking?

Neil, Chuck and Rocco Respond together:

Yes Yeah Yup

Yul Responds:

It's good. You get to see what other people are doing -

Chuck Responds: Yeah

Yul continues:

What other people are thinking and that's usually not what you are. So it's good.

Question: So it became apparent to you that people could have different views, or even similar views?

Yul Responds:

Yeah. It's just different ways of going about doing the same thing, which is very important when you're talking about systemic thinking, I suppose.

Question: But do you think it mattered that it was a blog and not something else?

Yul Responds: Nah

Question: Like the fact that you were able to say something in a blog rather than use another medium like a text document?

Chuck Responds:

I think it was better having an informal blog to write your thoughts, in a structured way, of course. It felt like less pressure to perform, I guess.

Yul Responds:

Keeping it a bit casual is probably pretty important.

Leah Responds:

And it was more of a focus of what you were writing rather than the way you were writing it…trying to structure it in an essay style.

Question: When you looked at the questions did it appear that the emphasis was always on the thinking behind it rather than just the responses? Was that apparent to you? Or did that become apparent over time?

Rocco, Neil, and Leah Respond and repeat in quick succession: Over time, Over time, Over time.

Rocco continues:

I think it's a bit more useful to get feedback on the blog like the one that you did after the second one…you said like…oh this is what other people answered because we only can see what within the group other people write and most of the time what I see is that when the group have a dominant thinker. Somehow everyone's blog matches the style of that person. I think it's better to compare your group and other group and I think that will improve how people reflect on what they want to write as well.

Yul Responds in agreement:

Hmm…Because we already get to reflect on each other in the discussions anyway.

Rocco Responds:

Yeah

Statement: I noticed that a lot of the people were not commenting. It seemed positive, but not overtly critical. I don't mean negative.

Chuck Responds:

Regarding comments…to reinforce it more and get people doing it. Also like when we were doing presentation skills we were doing like…you have to say one good thing and one thing to improve; one compliment and one gift.

Question: Commenting has been difficult. How do you generate buy-in for such a tool? You don't want to come across as being rude or negative.

Neil Responds:

I think that what Chuck said was very good. Almost like a mini version of the blog rubric itself. The blog rubric that you gave us really helped. It encouraged the sort of thinking

which was still very informal but encouraged the thinking with comments as well as through a structure.

Question: So you used the rubric for your last blog?

Chuck Responded:

Yeah

Neil Responded:

Yeah…helped so much

Question: It really helped you structure what you were thinking about?

Neil Responds:

Yeah. It helped structure systemic thinking, which was nice for me anyway.

Rocco Responded:

Maybe instead of commenting on your own group, rather comment on another group ((referring to previous statement about dominant thinking in groups)) But if you look at other groups…oh…I didn't consider this, I should have considered that. Or that you should have considered this because we considered this.

Neil Responds:

Yeah! That'd be great!

Snippet 8

Question: Do you think systemic thinking is an individual thing or would you prefer that it becomes more effective as a group activity?

Neil Responds:

It should be a group thing.

Yul Responds:

Yeah, it seems a group thing.

Leah Responds:

As a group.

Neil continues:

Because you're learning a new thing anyway and you're trying to expand your mind and the best way to do that is to talk to different people because they are always going to think differently.

Chuck, Rocco, and Leah Respond in agreement: Yeah

Leah Responds:

Everyone has different ideas. And since you are supposed to see interconnections between things, it's always better to have more than one person.

Question: So in that way it ties in with the activities we were doing? Most of the activities in the workshop were group based, so that kind of adds to the element of having more ideas, more people, giving inputs.

Leah Responds:

I think it's better to have intergroup discussion because the group was created by us so they are people on the same wavelength. For e.g. I find that the in-class discussion on food for thought is not as useful as I would expect because a lot of people have the same ideas. But as groups go on new points are added, and the discussion grows.

Snippet 9

Question: What do you think is actually difficult about being able to think systemically?

Neil Responds with a hint of laughter:

Clearing your mind. ((Hint of laughter))

Question: Clearing your mind?

Neil Responds:

Yeah. Sometimes you're stuck in a rut, in one thing…why can't I think of anything else. I guess it comes down to prompts - what do you say to yourself to remind yourself…oh...this is how I think systemically.

Question: Where would you see those prompts coming from? These are like questions you'd ask yourself, like trigger questions?

Neil Responds:

Yeah. I guess it ties in with structure…like people, plant and environment…

That could easily be something you'd have people to do…have a one paragraph could be dot points…of…what are your personal trigger point questions. You could make it worth marks. Or not… Show it now. Give it to me now, you have five minutes….give it to me now. It's not like along progressive thing, if people want to keep it updated they can if they are motivated enough to.

Appendix 13.   Transcript of Group Interview 2 held on 11 June 2012

This document contains selected snippets from the transcript of the Group Interview Meeting 2 with 7 student participants. The Group Interview Meeting 2 was held on 11 June 2012.

Questions in bold black print were asked by Interviewer and Research Investigator

Pseudonyms for Participants: Kye, Dax, Ruhee, Pia, Ayaan, Farzaan, Rex

Rex was unable to attend the start of the discussion. It was only towards the end of the discussion, he joined in.

Snippet 1

Question: We've all had an experience of what systemic thinking might be. Let's discuss what you have taken from the unit, and what you think it is.

Farzaan Responds:

Well, what I think about systemic thinking is just some (.) like technical terms I would say like listing up some small things and joining them to make a big one, like broadening up or joining the related ones, I guess.

Pia Responds:

I kind of thought it was more sort of like identifying that everything affects everything else, interacts. I suppose it was good with the risk management because it was more like every aspect of the company affects the safety culture. Even other companies affect a different company.

Ruhee Responds:

Yeah. I kind of saw it like that as well. Like how you have one thing and a few other systems like he ((pointing to Farzaan)) said and how they interact and sort of affect one another. And it all becomes one bigger system.

Question: But then is it difficult to qualify what this 'everything' is such, like you said, everything affects everything else. It is very broad in the beginning. How would you be able to narrow it down so that you have a way of starting to think systemically? What do you guys think?

Dax Responds:

Well, it is more like creative thinking. We are used to more quantitative in engineering. And this is more like you are trying to work out for yourself unknowns you haven't been told.

Snippet 2

Question: When I asked this question to the first group what they said was very similar about how everything affects everything else and the discussion then kind of led on to what they considered to be these trigger ideas. Because the system is so large, there are so many interconnection and interrelationships, they said what's useful is for us to be able to classify certain things into systems. And they came up with the notion of you know of people, processes, environment as a suitable framework to contextualise thinking systemically. Would you think along the same lines?

Ruhee Responds:

It does make it easier definitely.

Kye Responds:

Umm ((agreeing with Ruhee)). Actually until you (.) we saw a, well I saw a, there was a diagram ((referring to SYSTEMS VIEW DIAGRAM)), I had a lot of difficulty in grasping what systemic thinking was. And that was in like week five or six, a fair way in. Until then I really didn't know you were talking about.

Statement: When I saw that diagram I was happy as well because it contextualised things for me. One of the most difficult things is to be able to visualise the system in itself because it is such an abstract thing.

Kye Responds with an Umm ((agreeing)).

Statement: When you're dealing with people, plant, environment, procedures and that sort of stuff, they are almost intangible.

Kye Responds:

I mean you're also dealing with engineers. We don't think in words ((Pia, Ruhee, Ayaan, Farzaan chuckle in agreement, Dax smiled))

Kye continues:

We deal with pictures, models, diagrams.

Snippet 3

Question: If you were to apply systemic thinking, what would be your approach? What would you do?

Farzaan Responds:

I would just start listing everything. And try and categorise it later.

Pia Responds:

Pretty much get everything out there.

Dax Responds:

I think you'd may be start off with the motives for certain things. You want to have safety but also you want to (.) you're making money and you also want to be satisfying these rules.

Kye Responds to Dax:

Umm, I guess that would give you system boundaries.

Dax Replies:

Yeah, Yeah I suppose. Those are like the limitations, the criteria you need to satisfy. That gives you a base.

Ruhee Responds:

I usually move really like you start off with how it affects maybe one person and then a group of people, and then its environment and then everything else around it including all the economic and financial aspects and everything else.

Question: So you kind of build on it from somewhere. It doesn't matter where you start, in a way, and then you make connections and let it grow?

Ruhee confirms: Yeah.

Do you see any conflicts in these approaches you have suggested? And whether these conflicts are useful in any way?

Dax Responds:

It just shows how people think differently. It's the same with any other unit. You'd have people trying to work out mathematical problems differently as well.

Ruhee Responds:

That's the beauty of it. You get, that's why, I guess, engineers work in teams because you have lots of different people thinking differently. And then maybe merge those ideas to come up with something even better than if you were to work on it individually.

Snippet 4

Question: Do you suppose that this way of looking at things systemically is applicable for pretty much everything or certain things more than others?

Ruhee Responds:

I think it's applicable to everything because I was talking to somebody the other day about some random topic and I was like you have to think in like every aspect that affects, you can't think of just the one thing that like how it affects just you. If you're going to do something, this is what's going to happen, this is what's going to happen. Then you've got to think of the repercussions in the future and blah blah blah. ((Ruhee blushes with a hint of self-embarrassment)) And I realised I was starting to nag him about safety. ((Ruhee giggles))

Kye Responds:

I think it depends on context as well. If you're doing a mass-balance you don't want to be thinking systemically –

Dax interjects in agreement: systemically

Kye continues:

You want to isolate the system and have it well defined. And you can do that in isolation with no impact on the greater system. But particularly when you're dealing with complex systems it is useful.

Dax Responds:

I guess sometimes it can be counterproductive if (.) like we were recently doing this project using this computer program Aspen Plus. And I try to think of that systemically would just you know really not work because it's an individual unit you're dealing with. It's got inputs and outputs and you've got to try and think of them individually.

Question: So as a skill although it is generically useful, it is useful in certain contexts more than others?

Kye Responds: Yep

Question: And there might be a skill involved in trying to recognise which context it works in rather than others?

Dax Responds: Yep

Snippet 5

Question: As far as our Risk Management unit was concerned, what did you gather to be the take-home message about systemic thinking?

Kye Responds:

Risk Management is complicated

Pia and Ruhee Respond in agreement with Kye: Yeah. ((Both chuckle in agreement))]

Question: Okay, Risk Management is complicated, but what about systemic thinking?

Kye Responds:

Well I suppose systemic thinking and risk management work well together. It's a (.) how do I say this (.) it's a good application of systemic thinking in risk management because risk management has a lot of factors that come into play.

Statement: Okay

Ruhee Responds:

And I also found that it helped when you're sort to trying to tackle a problem. You're able to sort of look at things (.) something in isolation, assess it, and then also (.) then later take into account everything else that affects it, and works around it. I found that very convenient simply because other units they don't guide you into thinking that way. It's just like alright here's some stuff to do ((Ruhee gestures assertively)) and that's pretty much it.

Question: So in this unit you felt that there was guidance to proceed to think in this manner. And that was the result of the way we did things?

Ruhee and Dax Respond in unison: Yeah

Dax adds:

You ended up thinking critically. ((Kye nods and hems affirmatively in response to Dax))

Ruhee Responds to Dax: Yeah

Dax continues:

You look at something in a distrustful way and you'd look for things that were wrong or you'd look for things you could improve on.

Ruhee Responds to Dax: Yeah

Was this a gradual process for you? Like you began to recognise that there is more to it (.) there is more for us to apply to it rather than this is the approach you'd have in week one? Across the weeks it started to become clearer?

Ruhee Responds:

Yeah it did. ((Ruhee nods in agreement)) Definitely. The Food for Thoughts definitely helped. I'd read up around the topic and sort of force yourself I guess in a way to think and to (.) it also helped in terms of discussion. Even outside of class we would actually get together chat about it over lunch or something. And I found that it helped.

Pia Responds to Ruhee: Yeah

Kye shares his view on the Food for Thought:

I think that food for thought…what it does is give you concepts which is something we don't get much of.

Pia Responds in agreement to Kye: Yeah

Question: When you said concepts, what do you mean exactly?

Kye Responds:

A good idea of what's going on, even if you don't fully understand what's going on.

Pia supports Kye by adding: You can answer the questions.

Kye confirms in reply to Pia: Yes, that's right. Yeah. Yeah. And the fact that you've gone and looked for it yourself rather than someone else going this is what it is ((Ruhee hems in agreement because a little earlier she mentioned this same point albeit in her own way)) it changes it.

Ruhee Responds to Kye: It makes it stick a lot longer.

Kye Responds in return: That's right. Yeah.

Question: So it's a good thing for us to give you guys the opportunity to spend time by yourself ((Kye hems in agreement)) rather than have a bunch of -

Ruhee interjects with a chuckle: information spoon-fed

presentations.

Kye responds:

What I found with a lot of those is, I sat down, because I had to do it and like once you get yourself sitting down and looking at it, you start going all over the place because you start getting interested in it. It's being given that and knowing that there is a deadline, you have to look at something and hand something in. It's just that prompt to get you to do something.

So it's give you the opportunity to make connections and but it's also making you think about how much time you have to invest in it?

Pia Responds:

Yeah, I wouldn't spend too much time on it.

Kye Responds:

The first one you gave us I spent a lot of time on it because I was interested. Although some were better than others. The one where you were able to choose between transport versus fixed operation, that was a good one.

Question: I think one of the good things from the assessments was they had some level of choice. You were able to choose what you wanted to invest in and go on accordingly. I'm not sure how much that benefits in terms of learning?

Ruhee Responds:

Yeah, I think it helps a lot. It sort of helped everyone become a little bit more (.) well for me anyway (.) a little bit more observant and become a little bit more aware of the things around me. Funny thing with that transport thing ((referring to a Food for Thought from Week 3)) just that to think about it, because it was like oh yeah you know, you would drive around and you wouldn't even think of maybe what could possibly happen that the petrol station. But then inside me it was like oh right, you know. A car could drive into the kiosk, the roof could fall down, the place could explode, you know, that sort of thing. But yeah, it was helpful in that respect in heightening my observation skills.

Snippet 6

Question: Do you see any use for systemic thinking as a skill or as an approach to thinking? Why should it be worthy of attention?

Farzaan Responds:

To help you think in a broad manner, say for example, safety, the elements of it, the factors, how safety can be promoted through communication and such things.

Pia Responds:

I think it's a good education tool. It was good like to teach us with (.) to help us grasp the concepts (.) to actually think about them.

Kye Responds to reinforce Pia's view:

Yeah, like, you like you actually retain it, and remember it. Isn't that style a true test of retention rather than just your ability to load up on information and then dump it on the page? And isn't that far more useful?

Ruhee Responds to Kye's Question:

I think so. Definitely.

Question: Which one?

Kye Responds: The ability to retain information rather than load it up and dump it on the page.

Question: But when you say retain, what do you mean?

Kye Responds:

I mean you actually have that… If you learn a concept you hang on to it forever. If you learn a bunch of maths you're going to forget it. Isn't that a far more useful skill? And if you look at it in terms of value for money, going into the work place, it's a far better message to give information to people.

Question: So it comes across as being a useful way to learn a subject and particularly it seemed useful for risk management?

Kye Responds:

Well I think it can be applied to a lot of other subjects not just risk management.

Pia, Ruhee, Kye Respond in the affirmative: Yup. Yeah. Yeah.

Ruhee adds:

And later on it can be used to help with when we do our work and what not. This helps you cover as many things as possible in a sort of more ordered way ((Kye and Pia hem affirmatively)) rather than I mean oh yeah what about that! What about that? We were just like we'll cover this and this and this as we build on may be one aspect of it.

Question in Response to Ruhee's comment above: You raised this idea of order right as against something which is random and haphazard sort of thinking. What about systemic thinking makes it ordered?

Ruhee responds:

Being from a medical science background I see it as you know maybe a sort of physiological system? Like you start off with the cells, then you have the tissues, and then you have the organs, the organs make up a system. So it's sort of that way. It's how I see things, start off with something really small and then you build on it and then it affects that…the brain works with the lungs and that's two systems working together to (.) yeah, so that's how I see it, the way I saw it, the way I applied it.

Snippet 7

Question: How were the reflective blogs useful?

Pia Responds:

I liked reading other people's blogs. I actually liked reading other people's blogs more than mine. And I liked working in a group just because you see how other people think. You see the blogs and see how they thought about it. You have to comment. If you were commenting constructively you had to try and firstly put yourself in their point of view so that you could comment on what they'd already said, which is difficult sometimes.

Ruhee Responds following Pia's perspective on commenting:

Yeah. Yeah. Yeaah! You don't want to piss people off. Some of my comments I sent them to the author first before posting them because you don't want to seem like you're attacking them.

Question: Did it define your thinking; or rather refine your thinking?

Kye Responds:

I'd see people's point of view, but I still don't agree with it. It was just things I had to accommodate.

Snippet 8

Question: What was the benefit of those workshops activities for you personally?

Ruhee Responds:

New ideas from other people; obviously everyone thinks a certain way. Regardless of how broadly you think or whatever you still have limitations to the way you think. And then when you have other people give or present their ideas, there's definitely that benefit of "hey I didn't think of that to begin with". Then I guess the whole round table discussion and then later on that sort of condensing it on the board and finally summarising it, I think that was very helpful.

Dax Responds:

Yeah. I thought it was good. It was a good cure to the problem where you find that people could choose their own groups. People generally congregate in groups that they think similarly to. So people in one group would have all thought one thing but another group would have been completely different.

Kye Responds:

I thought that was quite interesting when you had the different opinions from different groups because groups would form consensus maybe. I mean we never formed consensus on anything, we were always debating. But there'd be other groups that had formed a consensus that was maybe at odds with other groups, and then seeing that the different perspectives is useful I guess.

Snippet 9

Question: Why do you think systemic thinking is hard?

Ruhee Responds:

You need to buy into it. You have always thought a certain way your entire life pretty much and then there's this whole other way of thinking. It's not difficult to get used to but just because it's different, it's very difficult for people to break out of their habits, so to speak, because the way you think is a habit.

Rex Responds:

People don't naturally care what others think. As a kid all you think about is yourself, "it's my ball, it's my toy or whatever", and then you get forced by your parents to sympathize and empathise with others and you consciously and to an extent subconsciously do that throughout your adolescent life. And then when you come to this

you are expecting to do that in a work environment as well, which you obviously do in a work environment. But this is a whole new level. Like bringing that whole empathy all the way up again, which is a bit unnatural for the majority if not all of the people.

Pia Responds:

People don't care about what other people think. But I think this kind of made it obvious that it is actually beneficial to listen and care about what other people think.

Appendix 14.   Transcript of Group Interview 3 held on 12 June 2012

This document contains selected snippets from the transcript of the Interview Meeting 3 with 1 student participant. The Interview Meeting 3 was held on 12 June 2012.

Questions in bold black print were asked by Interviewer and Research Investigator

Pseudonyms for Participant: Viggo

Snippet 1: Personal Understanding of Systemic Thinking

Question: What have you understood about systemic thinking from your experience so far in the unit?

Viggo Responds:

Initially I didn't actually understand what systemic thinking is. I know what systematic is so I keep getting confused what systematic and systemic because I thought they were the same thing at first. Towards pretty much throughout the unit I didn't really understand systemic thinking. Only towards the end when we had to write the reflective journal on the systemic thinking, we had to relate. Then I had to actually go and research more about it and do more readings on systemic thinking then I understood what systemic thinking is.

Question: In your perception what was systematic thinking?

Viggo Responds:

Systematic, from my understanding is like, a set procedures (.) for thinking. Or you follow, say (a short pause) um systematic. Systemic is like you're looking at the whole system. And you're relating everything into one part of the system or more. But systematic is only one branch of it where you think of it systematically as in procedure wise, one after the other.

Question: So when do you suppose this notion that you could, that, initially you felt that they were both the same and then therefore you kind of felt confused about (.) what, is that a different term. When did it start becoming clearer for you? And how did it become clearer?

Viggo Responds:

When I actually started doing the reflective journal; when I did more readings on it.

Question: So it is the blogs that made[Yes the blogs] the difference, not the other activities?

Viggo Responds:

The activities yes. But it wasn't emphasised. I didn't feel it was emphasised with systemic thinking point, you know. I felt like the activities were there so we could learn what risk management is but I didn't really feel like the emphasis on using systemic thinking to approach the risk management problems.

Question: Okay in your perception, you felt you were applying it in the blogs or in the writing of the blogs [Yup] I suppose?

Viggo Responds:

No I mean like, in class and all, I thought that we were actually using it but I didn't know that we were using it.

Question: Ah, okay. So now that you think back at it, [Yes …(inaudible)] you think that you using it?

Viggo Responds:

Definitely. Especially in the group discussions and all because it's quite broad, you're thinking about the whole system.

Question: So your perception changed [Yup] in the sense that you initially did not believe that you were thinking systemically [Yep] but in fact now in hindsight you recognise -

Viggo Responds:

Because I understood it a bit more. [Okay] And I thought about it and we were actually using it.

Question: When you said about the blogs that the blogs actually made it more clearer for you, was it the process of thinking for all the three blogs or towards the end of the semester that it started clicking?

Viggo Responds:

Towards the end of the semester.

Question: So in the previous two blog attempts how was your thinking systemic or not systemic?

Viggo Responds:

It was systemic but I didn't even notice it till later on. It became apparent that I was using that approach because before that I did not understand what systemic thinking was so I was just thinking to write a blog that's all. Just doing it for the sake of doing it.

Question: Did you feel we were addressing the notion of systemic thinking in the workshop activities?

Viggo Responds:

Yes especially from the second one onwards. The first one, I actually remember that you defined it.

Question: Now in hindsight, how would you define your understanding of systemic thinking? What would it mean?

Viggo Responds:

It would mean if you're thinking of a problem you have to look at every part around it and consider how the parts around it can affect it. And what can it do to other parts around it. Is that the right way of thinking systemically?

Question: Do you think it's wrong?

Viggo Responds:

No not at all.

Question: Okay, why do you think it's appropriate?

Viggo Responds:

Because you need for every system or problem you need to consider factors that will affect it or else you won't have a broad (.) you be like not open minded. So you'll be stuck on one bit but you don't see the bigger picture of it.

Snippet 2: Personal Approach of Systemic Thinking

Question: What would be your approach towards applying systemic thinking? If you took an example for yourself, and you worked out on it, what would you do?

Viggo Responds:

I would first focus on the main issue. But then I will look into contributing factors that would affect the main issue that I'm looking at. And also what the issue can cause to other parts of the operation.

Snippet 3: Systemic Thinking as Generic Engineering Skill

Question: Do you think systemic thinking is a very technical skill? Or a generic skill?

Viggo Responds:

It's a generic skill.

Question: In what way do you suppose that it is generic?

Viggo Responds:

Because personally I feel that most people already use systemic thinking, most people not all. But the problem is that they don't notice that. I don't think many people actually notice that they actually think in this way, systemically. Like I said during the first blog, I didn't know I was using it; until the second and third when I started to understand it a bit more. And I see what kind of method I was using to write the blog.

Question: In what way do you suppose it might be useful in an engineering context?

Viggo Responds:

Engineering, I reckon. In engineering, systemic thinking is a generic thing for engineers because they need to consider so many things. They can't think in only one way, because if they approach things at one way you won't find problems to your solution. In [engineering] (.) there is no best or ultimate solution. There's a few solutions that you can, engineers look for. That's where you look at the system around it.

Snippet 4: Personal Understanding of Systemic Thinking

Question: As far as the unit is concerned, what did you take away from it about what systemic thinking is?

Viggo Responds:

The problems that we did I find that we had to look at an overall perspective not a localised problem. You need to be knowledgeable of the field to use systemic thinking effectively. Because the limit to systemic thinking in my opinion is the amount of knowledge you have within the system, of the system. The less knowledgeable you are, the less factors that you know of. So the less, I guess, I don't know the word to use. I mean, if you know more about the system you get more information out of it. Hence get a better solution. I guess the easiest way for them to understand systemic thinking would be to look at the whole system.

Question: But how would the person know what the system is really?

Viggo Responds:

Viggo Responds:

That depends on their background, if they have the knowledge to it.

Statement: But then, they need to know what a system really means.

Viggo Responds:

Yeah but everyone has an understanding for a certain kind of system, like a system in their life. Like brushing your teeth in the morning. That's a system.

Question: Is it?

Viggo Responds:

I mean it's a procedure. But it's also a system where you need certain things. You need a brush, you need toothpaste, you need a mirror or whatever, you need water. You need to consider all that. Everyone has some kind of system in their life. You know what I mean, it doesn't have to be engineering related.

Question: That's interesting. I really like that point. And that's a really good way of looking at it in terms of how systems are pervasive in real life. That's a wonderful example. You mean to tell me that we are already a part of a system?

Viggo Responds:

A system or many, many systems; even if we don't know it. That's why you need to (.) if people don't know the meaning of system is, they would probably need to acknowledge it first before they can actually understand what a system means.

Question: And how would someone acknowledge that?

Viggo Responds:

They need to be told, or learn. They need to learn because I don't think. Like if you ask a kid they wouldn't know what a system is. Everyone learns what a system is. I found out what a system is in first year of engineering. Before that I didn't actually know what a system is. I had been hearing it but I didn't really understand what a system is. To know what a system is you need to acknowledge that a system does exist in a lot of forms.

Viggo continues:

In this unit I actually started to understand more the notion of system. This unit actually broadened my understanding of systems. I think to learn it people need to be exposed to more examples of it. There are so many types of systems that you can't just say one system is the definition of the others because it's different.

Snippet 5: On Discussions

Question: Did you experience a change, or increase in your understanding, once you came into the classroom and discuss with your group mates?

Viggo Responds:

I found it really helpful because when I came to class and we had discussions I understood it a bit more. If you do a bit of study at home of that topic and you come and discuss it, it's easier to absorb it…Because what I learnt at home, the effort that I put in was on my own understanding. It might be different to other's perspective. So when we came to discuss and we all thought about it, it defined the topic a bit more. I noticed that opinion plays a big part as well.

Question: In what way?

Viggo Responds:

If you have an analysis I would have a certain opinion about whether we should consider an aspect of the problem. But someone else might say, don't worry about it because that's not a major part of it.

Question: How does that affect systemic thinking?

Viggo Responds:

That's where the boundary comes in. You need to know where the boundary is.

Question: So in a sense, what you're saying, if I can interpret it correctly, it is that opinions will affect what boundaries you make?

Viggo Responds:

Yes definitely. Opinions are usually based on beliefs, I guess, individual beliefs.

Snippet 6: Relationship between Risk Management and Systemic Thinking

Question: What would you say you understand from risk management?

Viggo Responds:

The weekly activities and everything in the unit builds up understanding. Most of us are not familiar with risk management at all. So it built up from the definition of it and we started to get in depth with the material and built a bit more through actual cases. That helped us apply the basics from the start. I felt that progression from familiarity, to knowing, to understanding. We were not familiar with safety analysis that we were given. So we got familiarised with it. Then we know it, and then by applying it we got to understand it a bit more.

Question: What would you say you learned from risk management? What about systemic thinking would you take away from risk management?

Viggo Responds:

Before this unit I didn't know that you have to consider all those external factors for risk management. But in doing this unit I noticed that even legal terms play a part in risk management. Or something unrelated can be related. And there's no set procedure into risk management. There are different approaches for it. I learned that there are so many

procedures in tackling risk management problems. But I understood that we needed systemic thinking to approach these problems.

Snippet 7: Reflective Blogs and Thinking Systemically

Question: When did you feel most confident that you were doing systemic thinking?

Viggo Responds:

When I was doing my own reflective journal or the test, that's when I actually (.) Because I was conscious that I was using it. But during discussion we might, might be using it but we didn't actually think about that we were using it. I think it came naturally.

Question: So you were aware that you were trying to think systemically during tests and reflective and not during discussions?

Viggo Responds:

Yes, not during discussions because we were more focused on the problem itself. So we didn't actually, I mean I didn't actually focus on using that concept. I had the word systemic thinking in my head when I was working on the blogs.

Question: You mentioned that you were conscious of applying systemic thinking in your reflective blogs. Did you notice any progression in your capacity to think systemically?

Viggo Responds:

As I went from second to third I noticed that I looked at it in a bigger, wider perspective. In comparison of second and the third, I noticed that the second one was still, my thinking was still narrow.

Question: What do you mean narrow? Give me an example of how your second blog was narrow in thought as compared to the third blog.

Viggo Responds:

Okay. In the second blog I was thinking of one system. I was looking at one problem, like the problem was that incident in England. I looked at one part of it individually and then I wrote about the individual parts around it. For the third one I actually looked at how

systemic thinking, I looked at the overall thing, and related everything to one another. I actually defined systemic thinking in that blog.

Question: And how did you manage to make that leap from the second to the third? Was there a reason for that?

Viggo Responds:

Yeah because of the question set in the third blog. The question itself allowed me to further elaborate systemic thinking. Elaborate and understand it as well. It asked us to write about how did you use systemic thinking to conceptualise safety culture. So I had to do a bit more reading on it, go through internet google whatever and read a bit more about systemic thinking. And from there that's when I really, really differentiated systematic and systemic. I actually got a different definitions and comparisons of it between few websites. That's where I really broadened my thinking and thought of it as a bigger system, because of that question.

Snippet 8: Systemic Thinking for Learning and Understanding

Question: What do you think we would use systemic thinking for, as against any other type of thinking?

Viggo Responds:

In terms of exploring I guess. Identifying more of the system and considering more of it rather than being very localised.

Question: As a learning tool, would you say systemic thinking is a good and useful approach to learn something?

Viggo Responds:

Sometimes it is. Because sometimes if you use systemic thinking to learn, depends on the time you're given. Because systemic thinking requires you to learn such a broad spectrum, I don't know if that's the right word for it, broad field. But if you follow a systematic way you can go directly straight to the main point. Because it really depends on the amount of time you're given to learn something and the depth that you wanted to look for. If you look for bigger depth, more, more in-depth, you probably go with systemic thinking.

Question: And you said that it is time dependent, that the ability to thinking systemically depends on the amount of time you're given?

Viggo Responds:

Yeah. For a technical unit you study for you go with a systematic way of studying it rather than a systemic because it can relate to so many other topics. Systematic is focused and systemic is broader.

Question: Do you think we used systemic thinking to understand the unit and the things about the unit?

Viggo Responds:

Yes. But I don't think that systemic thinking allowed us to go in-depth. As in we touched on so many things like Nicoleta went through so many materials but we didn't really go into directly into and focus on one particular subject. So we wouldn't be, I guess, an expert on something. It would be a broad overview. That's what I find what I learned with the unit.

Question: So in a way, if we go back to looking at what you said about systematic and systemic and how systematic leads to exploration in a focused way and systemic would be a bigger picture, So then what we managed to do through the unit was provide the bigger picture not necessarily the focused way.

Viggo Responds:

That's it.

Snippet 9: Consciously being systemic as against being systematic

Question: Do you think that being systemic or systematic is a very conscious effort?

Viggo Responds:

It can be. It can be. To me now it is. But prior to knowing what systemic thinking is, it's something that you do it naturally. So you don't plan for it. It just happens. But now that I know it I know that I'm doing it. So I just follow that. But I know where to use systemic and where to use systematic.

Question: Do you think that thinking systemically, but consciously thinking systemically, has a different result from thinking systemically without awareness?

Viggo Responds:

Yes. I think you're more focused on what you're, the way you're thinking. As in, am I? You question yourself is this the right way of thinking, if I am using systemic thinking? And is this the right approach to think of the particular topic?

Question: Alright. So what you're trying to say is that focused attention is actually making you question yourself?

Viggo Responds:

Question yourself. Yeah. Question yourself is this the right method to approach this topic.

Question: And what effect does that have on your ability to think?

Viggo Responds:

Your ability to think will not change but after thinking you'd see the result of it. You have a better view of the result you get.

Statement: I quite like what you mentioned about how being more focused, being more attentive, is actually leading you to question your own thinking and that although it may not necessarily lead to a change in your thinking but it may make you think more.

Viggo Responds:

Yup. It makes you think more and the result that you thought of you'd be able to see it in a systematic way like in comparison to previous ways that you don't know what's like you're just doing your work. You don't see a picture of it.

Is there something to systemic thinking which is different from other ways of thinking that you've been used to?

Viggo Responds:

It's not something, personally, It's not something that I'm good at because I'm more of a systematic thinker , as I have been told. I usually follow strict guidelines. But I see that

systemic thinking is a very useful approach to thinking of problems or matters because it helps you be a bit more flexible in your thinking methods.

Does that mean that as a result of this unit you had to make an effort to think differently from as said you said you're naturally more systematic?

Viggo Responds:

Yep. Naturally I'm more systematic although there is some systemic thinking that I've done before that. I'm systematic but I noticed that systemic thinking can be very useful, through this unit. Because I noticed like systematic can be almost robotic; the way you think of stuff that you don't consider other factors. You need both. Systematic is something that people practice and they use. But systemic thinking is something that you need to sit down and then reflect on it and look at the bigger picture rather than following just something that's being practiced.

Snippet 10: Systemic Thinking for Learning and Understanding

Question: Were you satisfied with the way we did things in this unit to develop systemic thinking?

Viggo Responds:

Yes. The activities definitely did help us develop systemic thinking.

Question: Why do you suppose the activities were more useful for you for systemic thinking?

Viggo Responds:

Because we were using it; practising it.

Question: So it was the practice element that?

Viggo Responds:

Yep that allowed me to develop the understanding for it. By doing it I actually could relate to systemic thinking.

Question: Do you think that it is easier to understand systemic thinking by practicing it?

Viggo Responds:

From what I noticed most people by doing would learn better. But there are people, it actually depends on individuals, where some people would learn better from being taught or learning or listening. Personally I learn better by doing. I noticed that through this unit but other units as well. By doing it I actually understand it better.

Question: Was systemic thinking useful in any other units?

Viggo Responds:

No most of my other units were technical so I had to approach it in systematic way, more systematic. But yes, of course, systemic did play a part in terms of researching more materials for better understanding. But in terms of technical problems I had to appreciate it in a systematic way.

Question: So you were using systemic thinking to learn the theory of other units?

Viggo Responds:

Yup.

Question: Why do you suppose it is useful to studying theory?

Viggo Responds:

Because theory can be quite a broad thing and a broad aspect of a unit because to understand a problem you need not just one part of a theory, you need to say understand how to drill a well, you also need to understand the surrounding. Well reservoir porosity, reservoir permeability, the properties of the reservoir itself. So you need to know, understand those theory points so you can use systemic thinking. We need to consider them. If you think systematically that means you're going from the drill to the well bore and then to the first part of the rock and the next part of the rock. That way you won't be able to summarise it to give an average. Systemic thinking would give you a better understanding of the overall picture which gives you an average which you can work with.

Question: You make an interesting point. The way you're putting it you're saying that you were thinking systemically about the theory in this particular unit. Was the unit actually taught in a systemic fashion?

Viggo Responds:

No it was progressive, it built up. They taught us the basics first so I guess that was systematic.

Question: So you were taught in a systematic way but you were applying systemic thinking in your own way.

Viggo Responds:

In terms of solving a problem you need systemic thinking. You can't just look at that, you need to read the whole question and you need to look at the overall picture.

Question: The way the actual unit was done it was more systematic but they wanted you to think systemically?

Viggo Responds:

In terms of teaching. Yes. But we didn't know about it. I think so that it's something that they expect. They assume that we know how to apply systemic thinking. It's actually most of the units as much as that one.

Question: But that's a good point, don't you think? That a unit is taught in a systematic way but the expectation on you is to approach it systemically when you do tests or problem solve.

Viggo Responds:

But you're not taught how to do systemic thinking. We were not taught how to think that way. It's like they assume that we already know how to think that way.

Snippet 11: Systemic Thinking as being hard

Question: What would make systemic thinking hard to apply?

Viggo Responds:

Habit, I guess. Habit like if people have the habit to use systematic thinking then may be its hard for them to think systemically. I am a systematic person usually but now that I know what systemic is, I know when to use it so it's better.

Appendix 15.   Transcript of Group Interview 4 held on 13 June 2012

This document contains selected snippets from the transcript of the Group Interview Meeting 4 with 5 student participant. The Group Interview Meeting 4 was held on 13 June 2012.

Questions in bold black print were asked by Interviewer and Research Investigator

Pseudonyms for Participants: Avi, Ray, Rhea, Reece, Nolan

Snippet 1

Question: What I'd like for us is to begin telling all of us what you think systemic thinking is, what you have understood about it from the unit or just your general understanding. Anybody can start.

Avi Responds:

I'll start. The way I understood how systemic thinking works is probably like, looking at an aspect in like looking at it from different perspectives; and more or less just being thorough. Systemic thinking should like involve everything from the top from the biggest to the smallest.

Nolan Responds:

Let's say we look at this, this situation. You don't look at it as just this situation only. You look at what sort of factors are affecting, what can it affect, and what are the outcomes and all that.

Ray Responds:

What I think is that you see it by itself. You find out what it is about and after that you try to relate how it interacts with the other factors involved. This situation, you break it down and look at the tiny little events that link to it and see how they interact with one another.

Snippet 2

Question: Would you consider yourself to be or learning to be a systemic thinker?

Avi Responds:

For myself, I consider myself to be just starting. I now understand that there is a concept called systemic thinking and I'm starting to learn now to be a systemic thinker.

Question: Do you think it was difficult in some sense?

Avi Responds:

For my second and third year or even first year all the units were about just crunching numbers, working out calculations. So it wasn't like I was supposed to use systemic thinking. It was more like regurgitating what I've learned like concepts and so when fourth year came and I started risk management it was totally different. It's more or less I had to change my personality as well in some way. Because like looking at risks and hazards, I never looked at them like in a way like realising that a hazard can have an impact on someone else. Usually I would think of it as impacting myself and that's what is important. Up (until) to I started risk management.

Snippet 3: On Workshop Discussions and Blogs

Question: Do you think the range of assessments and the learning activities that we had were able to demonstrate to you the usefulness and value of systemic thinking?

Reece Responds:

I would say the workshop is the best example for thinking systemically. But the activities in the workshop, like ford pinto and the second one on ethics, because how we have group discussion as a whole we are given like all the (.) what people think and then when someone points out something and then you just say, "oh, how come I never thought about it?" So that's something like you learn throughout the process. But it is also a good thing when you start to think (.) usually how I think about systemic thinking is that when someone gives an idea I try to link that idea as well, not only what I think about the topic. So we just make branches in thinking and that's how I think systemically in the workshops.

Avi Responds:

The workshops were challenging I think, like if someone gave out an answer it would be totally different from what I am thinking. I'd start thinking what made them what made

them bring up that sort of answer whereas probably the presentations we, more or less, came to one kind of like solution most of the time. We usually came to agreement.

Question: Did you feel you were able to demonstrate systemic thinking through those assessments?

Avi Responds:

In a way, yes. Like, for that other workshop, I think the second one, where one of the managers at Kudo Chem, for me it helped me to use systemic thinking. I had to think of the context of the issue, if I was there, and also relate it to happening in a different continent to where I am. There were a lot of issues that came into play, and I found like sometimes my first decision like my first impulse isn't like probably the best one until you consider everything.

Question: So you experienced that as a result of that particular workshop activity in your group discussion?

Avi Responds:

Yep.

Question: In what way were the blogs useful to learn something?

Ray Responds:

It helped me think systematically first. For that, to organise my thoughts and then put it down, like in a way that people can understand what I'm thinking and what I express.

Reece Responds:

Usually in any case that you understand something and you actually understood it well, you are able to put it in an understanding way, to be able to express it in your own way.

Rhea Responds:

For the blog you had to think about it. You get to comment and read other's journals.

Question: Was that useful for you?

Rhea Responds:

Yeah because they mention some points that you did not think about. So it's like you share thoughts also. If he writes something that's not right then you can comment on it.

Question: Did you personally pay attention to the comments you received or gave? What do you think about the whole exercise of commenting?

Ray Responds:

Basically it just showed that I didn't think in a wider perspective.

Question: Do you suppose it's useful to systemic thinking to have comments from other people?

Yes. Yeah. ((The participants were all in agreement on this affirmation))

Reece Responds:

How you comment on other people's work as well makes you think another aspect. For example if someone out this like a good idea in then I were to ask "how about this, have you thought about this that links to this?" Yeah.

Appendix 16. Chuck's Reflective Blog Response in Week 9

Safety culture is a latent but highly important facet of any society or organisation. I am fortunate to have had a stimulating exposure to safety culture through this course and vacation work experiences. During the third workshop, it became increasingly apparent to me the diverse and sometimes mind boggling experiences others have had regarding their individual work experience regarding safety culture and Health, Safety, and Environment (HSE) in general.

Our group consisted mostly of international students who had completed various casual and engineering work experiences in Australia and back home. Their experiences in Malaysia and Indonesia (countries with far larger populations and generally poorer people) included small companies who completely neglected safety to larger companies who would readily neglect their safety culture in order to save money. In richer countries, companies would not sacrifice corporate safety culture even during downturns because any slip up could prove fatal to the future of the company.

These cultural differences were astonishing - people are not valued as much as they are in developed countries like Australia. I am glad that I sat with this group of people because subsequently it allowed me to reflect on my own experiences and to critically review what safety culture meant to me.

My vacation work experience with Clough exposed me to a pervasive and highly ingrained corporate safety culture. From high level work to low level work; discussions with colleagues, meetings and so on, safety was always a priority and was never forgotten. The overarching safety program was "Target Zero - Zero Harm to our People, the Environment and the Communities in which we operate." This is a systemic approach to having a proper safety program because it recognises the influences and effects an engineering company has outside itself.

My work involved brownfields work on Barrow Island for Chevron - a Class A Nature Reserve and an oil and gas operator with incredibly high standards for safety and operations. Any work I did had to fall inside the correct procedures with Chevron, state environmental policy, the 10 Chevron tenements of Operational Excellence and safety and TIF -Think Incident Free, such as the PSV I designed and the site visit I attended. I was flown onsite to Barrow Island for a day - this involved strict procedures as described to me in a comprehensive HSE induction.

As a testament to the high standard Chevron upheld, every single person going onsite had to complete and pass the same induction - engineers, operators, cleaners, chefs and so on. My pockets and boots had to be free of dirt before boarding the plane, all cars on the island use a special key which connects to a satellite system that monitors location and speed all the time and reports back on how good the driver has been, and no non-intrinsically safe tools or instruments (like cameras) could be used within 15m of any operating facility or equipment on the island - only a few significant examples of the safety culture I was a part of through Clough as an extension of the client's HSE program.

Admittedly, not all of my experiences with corporate safety culture at Clough were this obvious to me. In February of my time there, the CEO Kevin Gallagher sent out a company memo regarding HSE updates and concerns. There had been an accident with a truck and it's access on a slippery slope in PNG where a worker had fallen and been badly injured. Kevin immediately responded with - we at Clough will deal with this issue ASAP by adding better access ladders to the back of all trucks so that this does not happen again.

His reaction was systemic - he knew that worker would not only be hurt but not be able to work to provide for his family during the time spent in hospital, and it reflected badly on the foreign engineers (Clough employees) working in a foreign environment as it could be seen that the employer can't look after its employees. Kevin also mentioned Clough's company goals for number of accidents per million man hours and how it was decreasing - a trend he wanted to continue in order to justify the stringent safety culture in place.

My discussions with the group in the third workshop allowed me to see safety culture from a wider perspective through the lens of what I already knew - it is only positive and always lends the organisation a good reputation through good times and bad. However, pervasive does not mean easy - it can be tiresome as an employee to go through all the motions every single time, and this tediousness is heightened when it seems pointless. That is why a systemic attitude towards it must be maintained always; ensuring each individual employee knows they are doing it for their colleagues, families, wider community, environment, society in general and not just themselves.

Appendix 17. Leah's Reflective Blog Response in Week 9

The issue that was explored in the third workshop had each of us assume a role in the management team of a chemical plant which plans to take pre-emptive action to maintain the confidence of our investors following extensive news coverage of explosions that had recently occurred at another chemical plant. The action to be taken was the exploration of what makes a good safety culture as a means of providing safety assurance to our investors.

It is essential for the reader to note that this reflection has been interpreted as a review of the methods employed in the analysis of the given case study and the conclusions that were drawn in order to ascertain whether the analysis was carried out in a systemic way.

The first step in exploring the case study was to define systemic thinking. The following definition has been developed from previous explanation in class and in independent reading:

Systemic thinking involves relating concepts together from a "parent" concept and also exploring the interactions between the smaller concepts and their individual and/or combined effects on the system and surrounding (Espejo, 1994). It also involves critical reflection on an issue to compare and contrast various viewpoints

The task was undertaken as a group, thus discussion promoted the identification of varying and often opposing view-points. An example of this is the responsibility of safe behaviour falling on each individual either through their taking responsibility or their being given the responsibility. We were able to identify that the former would lead to consistent safe practices while the latter would be more likely to encourage employees to cut corners and cover up their mistakes.

The opposite situation could also exist, where an employee chooses to take an unsafe action or they are forced by their superiors or peers to practice unsafe behaviour. Both of these situations can be seen as going against the general consensus but in directions. The former is taking risky behaviour in an environment where such actions are not promoted or encouraged and the latter is resisting the unsafe practices in an environment where such behaviour is the norm or even enforced through coercion.

Interconnecting various issues was done in the identification of five key elements of a good safety culture. The selected elements were: commitment, transparency, reporting, review and enforcement. For example the link between transparency and reporting can be drawn since useful reporting must be both honest and all-encompassing, i.e. nothing should be intentionally left out to mislead the auditors or the public.

The five elements presented above could also be considered our parent topics for the issues that had arisen from our discussion. As an example, we identified the need for follow through in the safety policies that companies propose. This falls under the topics of commitment and enforcement. Another issue was the necessity for peer or performance review of employees and external auditing of the company, which falls under the category of review. One of the other main issues discussed was the concept of consequence as we believed that if each worker had an understanding of the consequences of their actions not only to themselves but all other connected people and systems they would be less likely to take the risk. An alternative interpretation of the same concept is the resulting actions from a breech in safety policy such as suspension from work and legal proceedings.

An interesting point to note was that in hearing from each group their notion of safety culture, not only could we see recurring issues and create more extensive connections between the issues and concepts but were also able to identify what was omitted from each of our discussions. For example financial pressure to cut corners and conversely media pressure to remain "clean" for the sake of the company's reputation. Here the former is an internal pressure due to the company budget and the latter is an external pressure from those likely to be affected by an incident in the chemical plant, should one occur.

In conclusion, we were able to successfully apply a systemic approach to the analysis of the notion of safety culture in a group discussion where:

Opposing viewpoints were raised and interconnections were drawn between the issues and concepts that were identified.

Five main concepts under which most of the issues we had discussed could be placed were proposed

Common inclusions and omissions to our group discussions were identified

Reference:

Espejo, R. (1994). What is systemic thinking? System Dynamics Review, 10(2-3), 199-212. doi: 10.1002/sdr.4260100208

http://onlinelibrary.wiley.com.dbgw.lis.curtin.edu.au/doi/10.1002/sdr.4260100208/pdf

Appendix 18.   Samara's Reflective Blog Response in Week 9

Systemic thinking is a concept that was introduced to me towards the beginning of this semester and from discussions within the Workshops and classes my understanding of systemic thinking is that it is about considering systems to be a whole (not a bunch of independent parts) and recognising and appreciating the relationships and connections between systems and between systems and the environment of which they are a part of.

It is also about identifying, understanding and appreciating differences and similarities in viewpoints between people to try and gain a more comprehensive understanding of a topic and being able to recognise and hence approach issues considering other people's perspectives and the perspectives of other systems and/or the environment.

Workshop 3 for risk management involved utilising systemic thinking to conceptualise the notion of safety culture. The team had a brief discussion and threw around some ideas to work out how best to approach the task, we quickly came to the decision that we should appoint job positions that were likely to be present in a real-life situation and then go around the table introduce ourselves, introduce our job and what we think it would entail, discuss our own personal viewpoint on safety culture and how we personally would approach the task based on our own values then discuss how we as our job position would be likely to approach the task.

I found this approach to be very useful because it really forced you to consider how your viewpoint can be altered by things such as your experiences or your job description and it pushed you to consider the perspectives of a person who may have a completely different notion of safety culture than yourself.

My personal job description was the public relations manager so with this job description in mind and my own personal stereotypes and attitudes towards how a person with this job description would view safety culture and the things they would tell the stakeholders about the safety culture within our company I, and the rest of the group were able to effectively employ systemic thinking to the concept of safety culture.

The group had an effective discussion on what safety culture means to both ourselves and the person we were acting as and came up with a whole host of ways in which we could ensure that a good safety culture was in place within our company so that we could convey these concepts to the stakeholders in question, we also considered how

this discussion might change if the stakeholders were to change. Many concepts were discussed and whilst I personally agreed with many of them there were also a few that I found a bit harder to grasp.

I found it interesting that so many people in my group tended to focus on utilising negative consequences to enforce safety culture such as instant dismissal for not complying with the safety approaches or "safety culture" of the company because throughout my part time work and vacation work I have only really been exposed to situations where the safety culture of the company is enforced through reward and recognition systems.

At Officeworks there are cash (gift voucher) rewards for being the safety team member of the month (a position voted upon by all other staff members to reward behaviours that comply with the OH&S policies in place at Officeworks), and at Chevron there are cash rewards for completing well thought out and insightful assessments of personal safety in the workplace in the form of OSPREY's (a system where you are encouraged to identify unsafe as well as safe behaviours and have a discussion with the person performing those behaviours to make the other person obtain a greater appreciation for the way in which others view their behaviours and the way in which they fit in with the safety culture at Chevron).

After listening to those with the alternate viewpoints it became clear that negative consequences were more typically employed in the very high risk situations such as on oil rigs where noncompliance with the safety practices and culture is more likely to result in drastic consequences and the concept of penalties for noncompliance became easier to understand for me.

As discussed above, the team utilised individual variations in viewpoints brought about by defining job roles, we utilised group variations in viewpoints brought about by discussion of our own viewpoints and the viewpoints of our new found job roles, and we utilised class changes in viewpoint brought about by listening to other groups approaches to the task which varied from our approach. In addition our view of the importance of safety culture was also adjusted by reading the case study on the Japanese accident.

The group also considered the notion of a safety system and clearly defined it, considered the implications of the safety system on other systems such as the financial

systems, the public image of the company and the environment which further helped to improve my systemic thinking skills.

Comment by fellow student to Samara's reflective blog:

Very well written article, you made it very clear how you formulated your own interpretation of systemic thinking and then applied it to safety culture. The exercise you completed in the tutorial sounds like an ideal method of altering one's point of view, as you pointed out. It is very reassuring to see your positive approach to safety culture. I wholeheartedly agree that ruling with an iron fist is a bad policy. It would surely result in operators working in fear of retribution and acts to reinforce the authority of management. Your examples of large and, to my eyes, historically safe companies are very good at demonstrating the value of cooperative safety reporting and communication strategies. I feel that employees would feel a greater sense of ownership and be more compelled to participate in these systems. Additionally, the cost of these rewards must pale in comparison to the cost of replacing employees at any sign of unsafe behaviour. I believe that company's consider each employee an investment, as regards training etc. and each lost employee must be replace, which will consume HR's time.

Appendix 19. Pia's Reflective Blog Response in Week 9

Attempting to define culture is kind of vague enough, without then trying to identify what makes a culture "good", or what makes any particular culture "better" than another. I'm sure everybody could in some way justify and argue why their culture is "better", without being entirely wrong. The point is that right and wrong, good and bad, are conceptualised completely through human thought, and again come back to how each individual person perceives their own world.

I remember reading some sort of astrophysics book a while back (and I do apologies for the lack of any valid reference) with a small section detailing how at some point in history a city in Italy chose to ban keeping fish in round bowls. Their argument was essentially that this distorted the fish's view of reality. All this kind of led to the question of: who are we to be the judge of what is real and what is not, or of what is undeniably right or wrong?

As humans we're completely bound by what we're physically capable of knowing and experiencing, and who are we to say that our own eyes don't provide us with a distorted lens through which we perceive our world? In my opinion this can often be the case when it comes to individuals. Often until we have been shown or opened up to a different way of thinking or looking at a particular situation, we're likely to glorify and follow completely our own way of thinking based on what we have known up until that point in time.

Tying this back into the theme of safety culture, I suppose my perception of what aspects should be included in a particular safety culture to make it "better" than one devoid of these same attributes comes down to how effectively the culture achieves its purpose, i.e. reducing workplace hazards and their associated risks, raising safety awareness and caution, and just generally improving the overall corporate safety of an operation.

An open mind tends to come in handy when attempting to idealise something as ambiguous as a good safety culture. In this sense, I was lucky in our workshop to be surrounded by a highly diverse group of people, with a huge amount of different views, experiences, and knowledge to share. One's opinion of what constitutes a good safety culture is indeed a function of their own personal background and experiences, including their heritage.

With this in mind, my group and I decided that listing off and taking into account the cultural backgrounds of each member was of importance. After an extensive discussion, the class managed to produce a list of five important "safety cultural traits" which I completely agree with. These were: transparency; incident reporting, or choosing to report; enforcement; review, both self and organisational; and commitment to the culture.

I think not just laying the foundations of an effective safety culture, but also ensuring it continues to be enforced to the same extent across the entire organisation is largely important. In addition, when employees are encouraged by management etc. to report any safety issues of concern, the overall safety culture of the organisation is likely to be more prominent, and given a little more meaning.

Educating employees the level of acceptability when it comes to workplace hazards and following procedures is one thing, but if no one demonstrates this required behaviour to employees at a lower level then what is the point? I think one of the biggest ones for me is review, not just external auditing but also self-review, including employee feedback. Organisational requirements change, as do people, company objectives and conditions. A safety culture open to change and built with inevitable change in mind is one that will be most effective.

Anyway I suppose that's all from me, peace out everyone.

Pia's Reflective Blog Response, Week 6

Brian Harris' article "Directors' and Engineers' Responsibilities for Safety – a Cautionary Tale" raises a couple of ethical issues worthy of discussion. I suppose the most obvious issue centres on Brian himself, and whether or not he was ethically responsible for the death of the two men.

Ethics are a strange concept in that there is no real black and white definition. I'd very much liken ethics to morals, and obviously every person holds different morals based on their beliefs and values, which makes ethics such a difficult subject to talk about. In this case I would argue that Brian, the other managing director, and chairman were not ethically responsible for the deaths of these two men.

Having said this I am basing my opinion solely on the story told from Brian's point of view. From this article, I can gather that the company had an excellent safety culture,

Brian most certainly took safety seriously, and honestly believed he was doing all he could to ensure the safety of his workers. Unfortunately, he had little control over the workers themselves, and their set of values.

It appears that these two workers held a very different view on their own ethical responsibility in regards to the highly hazardous environment they were working in. They were cutting corners and not following safety protocol in order to make the job more convenient for themselves, as opposed to making the environment safer for not only themselves but also their peers. It's lucky that no other workers were injured in this explosion.

I think the fact that Brian even took the time and bothered to write this article to educate and make others aware of the importance of ethical behaviour shows that he is very likely a caring person, who would act ethically and for the benefit of everyone when put in charge of the health and safety of such a large group of people.

There is really only so much you can do when it comes to trusting your own employees to hold the same values of the company, and to carry out their job as instructed. I think being persecuted for 'lack of supervision' seems a little ridiculous when it comes to adult workers. Did these workers really need more supervision and a slap on the wrist in order to follow safety protocol that was in place for obvious reasons?

In my opinion the importance of ethics in our everyday lives, whether it be personal or professional, pretty much just comes down to doing what's right for the safety and justice of everyone. What's 'right' could potentially contradict itself when it comes down to what is best for yourself, for your friend, or the good of the majority.

Generally I'd consider acting ethically to be a relatively selfless act. For most people, I'd assume acting this way to be almost second nature, but I guess everyone's set of values differs just enough to mean that someone else, when put in the same situation as you, would behave and act completely differently. In a professional sense, it should be acknowledged that the actions of managers and supervisors especially can have a huge impact on the way the rest of the employees behave.

The entire company is interconnected in this way. It is up to those in charge to make it clear what the company considers to be right and wrong, and for others to follow suit. If any employees disagree with the values of the company then I suppose they should reconsider whether or not they should continue working there.

Shireen's Comment to Pia's Reflective Blog:

You make a good point about the limits of trusting in operators' personal work ethics, even when you know that they are adults and should be respecting the hazardous nature of the material.

You also make a nice point about the story being told from only his perspective. In my blog I worked on the assumption that, as it was published in an official trade journal and includes results of the investigation, it shouldn't be too biased. Now, reflecting on your blog, I wonder if the article could have been done for public relations spin (to clear the company's name by implicating the operators) as much as being a seemingly altruistic warning to industry.

I'm left wondering if there is more to this story and am reminded that we must be able to -demonstrate- a good safety culture and safety assurance. For example, how do we know what sort of training about hazardous materials was given? More importantly, how can we know that management made the safety culture something operators believed in rather than merely complied with, if it is not demonstrated?

Shireen (Pia's Group Mate) – Reflective Blog Response, Week 6

1.0

Brian Harris' article "Directors' and engineers' responsibilities for safety - a cautionary tale" heartbreakingly shows the importance of human error as a factor in risk management. It shows how lazy operators' wilfully unsafe behaviours ultimately cost them their lives, and proves that not only must ethical intention and behaviours be present in any engineer's daily life, but that they must also be -demonstrably- present.

The company obviously had ethical intentions in designing a seemingly thorough risk management system. As such it is a sad fact that, in the eyes of the court, Harris' greatest fault was to trust employees to follow procedures which would save their own a****! This raises questions about personal duty of care vs micromanagement.

Some ethical considerations include whether Harris was sufficiently knowledgeable to bring in better procedure assurance policies, why he did not, at what point he became responsible for operator behaviours, and what sort of safety culture was present that the operators were not confronted on-site about their behaviour. Transparency and

accountability about risk management protocols, audits and procedures were required to -demonstrate- ethical intentions, attitudes and behaviours.

The article clearly shows that vague ethical intent about risk management at management level is not enough. Instead, concrete evidence must be present to ensure that all levels of management are demonstrably involved in constantly evaluating risk and protecting each other, if only to cover management's derrières when idiots succumb to Darwinism. It's sad, really.

2.0

Why do human instincts encourage caring, why do we accept social pressures to conform by behaving ethically, and is it all a big con?

Clever people may note that ethical behaviours are not always in the interest of the individual on a short term basis; for example stealing a car makes more financial sense than foolishly paying for one! Wise people, by comparison, know that humans are social beings and that ethical behaviour forms the basis of a stable society.

We are evolutionarily hardwired to care for the crowd, accepting long term gratification and the furthering of society in place of short term gratification and societal damage, as we ultimately depend on the society for our livelihood. Thus ethical behaviour directly empowers society, ultimately empowers ourselves and because it's an evolutionarily natural human impulse, it feels good.

In our professional life:

At the lowest level, all engineers in Australia must operate within Australian law. However this is not enough, as on top of basic human decency, there is an inherent social license to operate that applies to any company enterprise. As a trusted profession, engineers are expected to aim higher than mere legal obligations.

We are instead required to abide by ethical codes of conduct like those set out by Engineers Australia. These ethical principles should guide decision making processes at all times in the workplace, throughout all segments of a project's lifecycle and at all levels of management.

As a decision-making body which deals with large-scale projects, engineers' decisions may either benefit or cost their company and the society in which it operates. We have a duty of care to ensure the safety of all stakeholders, including the general public.

In order to be worthy of trust, engineers must not only behave ethically, but must be seen to behave ethically by creating transparent, accountable approaches to safety and a good safety culture. We must hold paramount the safety of others, and reject decisions which are unsafe, or, from a cold company perspective, face public outcry at the least and company dissolution at the worst.

As the public's trust of individual engineers, engineering companies, industries and the profession is constantly re-evaluated, it is in any engineer's interests to operate in such a way that safeguards public acceptance and approval by always considering safety and exhibiting demonstrably ethical behaviour.

In personal and social life

Unethical behaviour in an engineer's personal or social life will inevitably raise questions about the ethics of their workplace decisions, whereas an engineer who aspires to ethical attitudes and behaviours in all spheres of their life is more likely to behave ethically at work. However, this is a poor reason for ethical behaviour, in that it is a false care cultivated by society and motivated by job security and thus financial advancement. A far better way is to simply follow natural human instincts to care for and respect others, to consider others' perspectives and the consequences of your actions - then ethical decisions come naturally!

In summary, ethics are important at work, home and play to help respect and empower ourselves (as individuals, companies, an industry & profession), and others. Ethics give a life approach which informs decisions, inspires trust & makes us worthy of it, allowing us to create & fit into a safe and stable society.

Pia's Comments to Shireen's Reflective Blog:

I like the point you raise that, an operator really does need to follow guidelines of a company's ethos, to which ethics is built in, otherwise everything just goes out the window.

I do have one comment to make on the personal and social life section though. I don't agree so much that following human instinct will allow us to act ethically; we are

animals after all so our instincts are to eat, drink and reproduce. I believe that yes, it is a poor reason for ethical behaviour just because society says so and to keep our jobs. But, for many people, that is the only reason they would act ethically, because society says they have to, otherwise they would be an outcast, and no longer fit into the society, that they just glide under the radar in.

I think the point that I'm trying to make, is that ethics, are an evolution of society, and not necessarily human evolution. And hence it's not really just as simple as following human instinct to care and respect, but maybe it is following a 'society instinct' to care and respect others, so that we as individuals, and cared for and respected.

Shireen's Response to Pia's Comment Above:

I think you are quite correct in what you're saying here about the difference between societal and human evolution; that was a point that I struggled to express clearly because to me the evolution of society is so intertwined with the evolution of man. Your last sentence sums up really well what I was trying (and failing) to say, so thanks for the clarification and cheers for commenting :)

Lennox's Comments to Shireen's Reflective Blog: I really like your comment on the fact that engineers' not only need to hold ethical intentions, but that they also need to be able to demonstrate these intentions. It's a pretty nerve racking thought considering most people struggle to even describe ethics 100% clearly. I do agree with Pia's comment that behaving ethically is more of an evolved, societal instinct. Essentially I think people are more incline to behave ethically purely because the society we live in actually makes it more difficult, at least in the long run, to behave unethically.

Lennox (Pia's Group Mate) – Reflective Blog Response, Week 6

Ethics is always hard for me to describe, and hence even harder to combine with safety. My understanding of ethics is that it is something that is developed over time, to ensure that the interactions of people with people, people with environment etc., can be accepted by society as a whole. So safety and ethics, is the development of a unwritten set of moral codes, relating to the safety of people, the environment, so that the general population can be happy that 'things are operating smoothly'.

For the article "Directors' and Engineers' responsibilities for Safety – a Cautionary Tale." by Brian Harris, 2004, there is a great discussion about his personal experiences for an

incident that occurred in Wales in 1988, where it would appear that negligence played a major part in the death of two people at an explosives production plant.

First of all the type of plant says enough about how paramount safety must have been, and explosives production plant. The fact that only two men out of 100 workers, died from the explosions at this plant, tells me that the plant must have been designed to the highest safety level, and hence the company acted ethically in the construction of the plant.

I believe that the company also acted ethically in the procedures of the plant, and the safety inspections of the plant. Quarterly inspections by the Managing Director, and weekly plant meetings should have meant that safety was on everyone's mind, especially when dealing with explosives for a living.

In my opinion, seeing as the procedures are laid out for the workers to follow, following the procedures becomes the responsibility of the individual to follow those procedures, as they have no gain from not following them.

My experience of working in at a pilot mining plant however tells me, that people rarely follow the outlined procedures, when something goes wrong, or if they have been doing the same laborious job, and think that they come up with a 'better more productive' way of doing something, without consulting management first.

To me this is unethical behaviour, as the person is risking their own safety, the safety of the people they work with, and the reputation of the company they work for, should there be an incident.

I think in the case of the two men that died because of the explosion, their death is their own fault, as they should have been following procedures outlined by management, and not risking the safety of themselves or others. Their actions seemingly only gaining them more time in the canteen and this is very unethical, as they were trying to get personal gain.

It can be argued however that their manager should have told them to act within the guidelines of the procedure, and possible provide retraining if required. But these mean should have already been trained in the procedures, and as it was their job, day in day out, the procedure should not have been forgotten.

To act ethically in the modern environment is of upmost importance, some will argue because political correctness has gone wild, or that people are becoming too sensitive. Though these arguments maybe valid in some situations, we all live in the same world, whether it be sensitive or not, and we all must act within the ethical guidelines that society gives us.

As people we do not put ourselves in harm's way intentionally, as we do not get any gain, but we may put others in harm's way for personal gain, maybe intentionally, maybe not, but it is still unethical to do so.

There are laws that bind us to behave; these laws are created from ethics and standards, to keep everyone safe. So if we all act ethically, and follow the laws, we will be happy, as we are not putting ourselves in danger, the people we live with and are friends with, will be happy as we are not harming them, and because we act lawfully and respectfully at work, we create a good working environment, as we are not putting anyone at risk.

I'm not entirely sure if what I have said makes sense, but my main point is that ethics binds us all on this world, and that if we all act ethically, and within our realm of ability, we can make it a safer and more enjoyable place.

Pia's Comment to Lennox's Reflective Blog:

I completely agree with your comment about operators taking shortcuts. I know from experience how tedious some procedures and pre-start checks etc. can get, especially for little things that seem to just be simple tasks. However I highly doubt I'd be compromising not just my own safety but the safety of other workers in a situation as serious as that outlined in the article. I suppose even explosive materials can be perceived as harmless when working with them day in and day out.

Shireen's Comment to Lennox's Reflective Blog:

I think you make lots of really great points in this article. I particularly like your comment about how low-level operators may deviate from official procedures if they think they've found a 'better' way of doing something.

In my opinion, creating more efficient ways of working shows innovation and initiative on the operator's behalf. As such this type of thinking should be rewarded, not stifled, however I agree that it is dangerous when operators make the change without safety approval.

Like you, I have seen unofficial potentially unsafe deviations in one workplace and at another workplace saw management fairly effectively combating the issue. The second workplace's approach was to make the official procedures very accessible, ask operators each week if they had come across a less-frequently used procedure which wasn't as good as it could be, and to get the operators to read & make recommendations about a different specific procedure each week.

This was good in that it gave us operators a chance to ask 'the higher-ups' -why- certain procedures were in place, discuss between ourselves how it could be improved (a popular topic on lunch break & nightshift when the operators didn't have much better to do), and then put these improvements to management. It empowered operators to critically assess everyday procedures for safety and efficiency, and allowed safe innovation by ensuring that all changes were officially safety approved.

Improving the procedures ourselves, in consultation with management, gave us a sense of ownership over the procedures. Management's dedication to open communication about the issue gave us a better knowledge of -how- procedures protected us, and ultimately created a better safety culture. I would recommend the approach for use at any workplace.

Appendix 20. Viggo's Reflective Blog Response in Week 9

As described in the presentation 'SYSTEMIC THINKING – a simple thinking technique for gaining system focus' made by Gary Bartlett, I strongly support the concept which systemic thinking is a combination of analytical thinking and synthetical thinking. In which was the method I have used to systemically conceptualise the notion of "safety culture"; by studying (analysing) all known elements of the "safety culture" system (including company/history/motivation, safety management systems, workers, procedures, influence, executive management and liabilities) and relating or involving (synthetic) them to one another as to the portrayal of cutting off a branch from a tree will also rid of the leaves it carries with it.

Noting that the elements listed are only based on my understanding and beliefs to safety culture, I acknowledge that there are different perspectives on the view of safety culture elements which us dependent on backgrounds and histories. In short, systemic thinking is to analyse and to synthetise; defining the identification of "safety culture" roots and bringing them together.

Safety Culture, an Australian Occupational Health and Safety service provider defines "Safety Culture" as a "mission to make Safety a way of life in the workplace". I strongly agree to this mission statement because it ultimately underlines the word "culture" as "a way of life". This gives me the understanding that "Safety Culture" is neither a practice nor merely just an idea but it should be something inherent within the workers of any company; one could use the phrase "that it becomes second nature".

Looking at a company as a system which gravely depends on "Safety Culture", we can immediately identify that the workers are the direct relation to its implementation. There has been a long-standing debate on whether "Safety Culture" is a core safety aspect for the operation of any operations organisations.

There have also been many questions on how can it be implemented or who in the organisation is "in charge" of defining "Safety Culture" or how far has does the notion of "Safety Culture" extend in terms of individual within the companies. To answer these questions we first need to understand what "Safety Culture" is. To my understanding, " Safety culture" defines a company's ability to ensure a safe environment through the response of all workers to the idea of safety and of their significant interest in the safety concept.

It is a "habitual" concept that should be inherent to all parties involved within any operational system/company. To compromise for the inherent aspect of the "Safety Culture" concept, we need to systemically analyse the worker relation network to identify which party is responsible for its implementation. Whether it is done through education such as workshops or inductions we need to consider which would be the best option in terms of ensuring longevity/consistency of the concept.

The responsibility of this implementation through synthetic thinking of systemic thinking, we link to the management team/executives who we hope are more experienced with the operational system to raise safety awareness. They firstly need to create a notion of "Safety Culture" if it's a " fresh" company or inherently influence/motivate the workers of the existing "culture" through safety management systems, reporting systems, monitoring and assessment of the workers notion if "Safety Culture". This would indicate the behaviours and responses of workers through tests scenarios.

As discussed in the workshop, an addition to the motivation such as incentives for upholding the right "Safety Culture" a converse form known as fear also exist. Workers/personnel not upholding the pre-set procedures and appropriate company "Safety Culture" are bound to legal actions or fines.

This is not considered a strong form of "Safety Culture" implementation because it only sets a minimum limitation as opposed to a motivation which gives a better " drive" to better or an "extra precaution" to maximise "Safety Culture". As stated in the article "Safety Culture: A concept in Chaos?" the terms workplace, entity and environment were used to generally define the concept of "Safety Culture".

Through this finding, I believe that a general view and understanding of the concept correlates to the idea that "Safety Culture" is a group based notion where it is related to the idea that its effectiveness within any organisation is only as great as the weakest upholding of the culture.

To conclude my findings through a systemic thinking approach, I conceptualised the notion "Safety Culture" to be based both on the company's and individual (personal) interest of safety and culture background. It is also respective and compatible to the each particular company which considers all parts of its operational systems and environments.

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http://www.humanfactors.illinois.edu/Reports%26PapersPDFs/humfac02/zhawiegvonshamithf02.pdf

http://www.probsolv.com/systemic_thinking/Systemic%20Thinking.pdf

http://www.safetyculture.com.au/

Appendix 21. Curtin University's Human Research Ethics Committee Letter of Approval for Project # SMEC-72-10

Memorandum

To	Rohan Karpe, Chemical Engineering
From	Pauline Howat, Coordinator for Human Research Ethics Science and Mathematics Education Centre
Subject	Protocol Approval **SMEC-72-10**
Date	5 November 2010
Copy	Nicoleta Maynard, Chemical Engineering

Thank you for your "Form C Application for Approval of Research with Low Risk (Ethical Requirements)" for the project titled *"Research into Learning and Assessment Interactions in ChE Risk Management Unit"*. On behalf of the Human Research Ethics Committee, I am authorised to inform you that the project is approved.

Approval of this project is for a period of twelve months **4th November 2010** to **3rd November 2011**.

The approval number for your project is **SMEC-72-10**. *Please quote this number in any future correspondence*. If at any time during the twelve months changes/amendments occur, or if a serious or unexpected adverse event occurs, please advise me immediately.

PAULINE HOWAT
Coordinator for Human Research Ethics
Science and Mathematics Education Centre

Please Note: The following standard statement must be included in the information sheet to participants:
This study has been approved by the Curtin University Human Research Ethics Committee (Approval Number SMEC-72-10). If needed, verification of approval can be obtained either by writing to the Curtin University Human Research Ethics Committee, c/- Office of Research and Development, Curtin University of Technology, GPO Box U1987, Perth, 6845 or by telephoning 9266 2784 or hrec@curtin.edu.au