

Knowledge Elicitation in a

Mixed Martial Arts Organisation

Peter Marshall

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May 2010

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ABSTRACT

One of the fundamental processes indentified in the field of *knowledge management* is knowledge capture. In capturing knowledge, it is essential that knowledge must be acquired from relevant sources. This can occur in one of two ways, through the use non-human sources (e.g. electronic documents, organisational databases, etc.) or human sources. Whilst acquiring knowledge from non-human sources can be useful, knowledge from expert human sources provides a direct means of identifying the key steps required in decision making. This process is known as knowledge elicitation. The current literature in knowledge elicitation is mainly concerned with capturing knowledge associated with skills at a cognitive level whilst relatively little research has been performed in capturing knowledge found in physical activities. In this research, we examine the current literature in the field and investigate the appropriateness of knowledge elicitation techniques in acquiring physical skill level knowledge. For the purposes of the research, we will look at acquiring knowledge of physical skills from an expert trainer in the field of *mixed martial arts*. Traditionally organisations in this field use a combination of the apprenticeship learning model and *socialisation* to teach physical skills to its students. The experiments will focus on acquiring procedural and strategic knowledge required to perform two fundamentally different martial art techniques, a throwing technique and a submission technique. Using an empirical approach to knowledge elicitation technique selection, elicitation techniques will be used and applied to acquisition of knowledge. The results of the elicitation will be compared against an initial demonstration provided by the expert. From this, we will be able to compare the knowledge elicited from each technique in terms of knowledge articulated, both verbally and non-verbally, to enable us to identify appropriate knowledge elicitation methods for the task. The process will be critically analysed in which conclusions will be made and the potential for further research identified.

Key words:Knowledge Management, Knowledge Capture, Knowledge Acquisition,KnowledgeElicitation,MixedMartialArts

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1. INTRODUCTION

"The introduction of many minds into many fields of learning along a broad spectrum keeps alive questions about the accessibility, if not the unity, of knowledge."

Edward Levi

1.1. Introduction to Research

As we move towards the goal of a knowledge economy, organisations have started to recognise the importance of their knowledge assets. In order to manage the complexity of knowledge, a field of research, Knowledge Management (KM), has been established. In their seminal work, Davenport and Prusak (1988) defined KM as a systematic attempt to discover, represent, distribute and use knowledge. By leveraging know-how, experience, and judgement both internally and externally to an organisation, KM aims to increase the efficiency, effectiveness, quality, growth, and speed of organisational processes (Ruggles, 1998), thus creating value from an organisation's intangible assets (Wilcox, 1997). This recognition marks a conceptual shift from traditional business values as organisations start to recognise its cumulative knowledge as being central to its performance (Drucker, 1993).

Like most companies, sporting organisations have an abundance of knowledge in all aspects of their business. Knowledge is required at a high level in strategic decision making, as well as everyday administrative tasks; all the way through to the grassroots coaching of its athletes. The relatively recent commercialisation of sport has seen the potential financial gains increase. With so much at stake, organisations must look at ways in which organisational knowledge can be exploited in order to gain a competitive advantage. To achieve this, a cultural change is required. Old organisational models must be replaced by new ones. Sports managers and coaches must look at the wealth of knowledge with exists both internally and externally to their organisations and find ways to harness it in order to benefit the athletes, the teams, the coaching staff and the organisation (Toohey, Halbwirth 2004). One such sports industry, which has seen significant change, has been martial arts and particularly a movement within martial arts itself called Mixed Martial Arts (MMA).

Mixed Martial Arts (MMA) is a full contact combat sport that allows a wide variety of fighting techniques, from both traditional and non-traditional martial arts, to be used in competition. The rules permit athletes to combine striking and grappling techniques, whilst fighting from a standing position as well as on the ground. This allows martial artists from different backgrounds to compete on an equal playing field. From its inception in the early 1990's, MMA has become one of the fastest growing sports in the United States, Japan, Europe and Brazil. The main industry player, the Ultimate Fighting Championship (UFC), saw its revenue exceed \$250 million in 2008 (Noel, 2008). The emergence of MMA promotional companies in new markets, such as China, Australia and Russia, has opened up the sport to an even larger and more diverse audience.

The sport of MMA has evolved from traditional martial arts. Whereas the early MMA practitioners trained exclusively in one art (e.g. Wrestling, Boxing, Tae Kwon Do, Kung Fu, *etc.*), today's modern mixed martial artists have had to embrace techniques taken from various fighting disciplines. Fighters who are unable to successfully combine techniques from a wide range of disciplines are at a distinct disadvantage.

1.2. Research Problem

Team Ryano in Baldoyle is a MMA academy that coaches students to compete in MMA competitions. Knowledge is a key asset extensively used in all aspects of its business. Instructors from different disciplines use their knowledge to teach skills, help their athletes apply strategies during competitions and improve their performance. The athletes themselves use this knowledge to acquire new and improve existing skills. In addition to the coaching, the organisation benefits from the collective knowledge of the group in tasks as diverse as scouting opponents to providing dietary guidance for

their athletes. This knowledge provides the organisation with a competitive advantage which has led to their success on both national and international level.

Difficulties arise in the acquisition of this knowledge, when the student fails to pick up the various nuances required to accurately model the tacit knowledge of the instructor. The difference between a student's knowledge and that of the expert's level is known as the "zone of proximal development" (Vygotsky, 1978). The hypothesis for the research is that elicitation techniques from the field of knowledge management can help reduce this gap, by exposing the tacit knowledge of an expert.

1.3. Project Aims

The aim of the research was to investigate the use of knowledge elicitation techniques, traditionally used to capture knowledge at a cognitive level, and to apply it to the acquisition of physical skill based knowledge, required in performing MMA techniques, from a subject matter expert.

1.4. Research Objectives

The following objectives have been achieved throughout the dissertation and contributed to the overall outcome:

- 1. An overview of the extensive body of knowledge that exists within the field of knowledge management.
- 2. The identification of relevant work done, to date, in the field of knowledge elicitation
- 3. Provide a background to the sport of MMA, both at an international, national and an organisational level.
- 4. Conduct experiments in which knowledge elicitation techniques, found in the literature review, are applied to the acquisition of mixed martial arts techniques.

- 5. Perform a critical analysis of the results in which the success of the elicitation techniques can be compared against the knowledge elicited from the initial demonstration of technique.
- 6. Reflection on the process, from which, conclusions and future work were indentified.

1.5. Research Methodology

For the purposes of this research, the following methodology was used:

- 1. Identification of valuable knowledge in the organisation
- 2. Identification of knowledge sources within the organisation
- 3. Creation of a list of terms to be used in the during the knowledge elicitation session
- 4. Identification of an appropriate set of knowledge elicitation techniques, to be used in the knowledge elicitation sessions
- 5. Capture of the initial demonstration of knowledge by the expert
- 6. Engage with expert in knowledge elicitation process.
- 7. Creation of steps required to perform the techniques from each of the elicitation methods.
- 8. Analyse and compare the knowledge extracted.

1.6. Project Deliverables

From the research, the following deliverables are presented:

- 1. A breadth of knowledge literature review focusing on the subject of knowledge management.
- 2. A depth of knowledge literature review focusing on knowledge elicitation.

- An overview of the sport of Mixed Martial Arts with reference to the Irish Mixed Martial Arts community.
- 4. Identification of the knowledge that exists within the Team Ryano organisation.
- 5. The experimental design of the experiments conducted.
- 6. A detailed account of the experiments (including the recorded footage from the initial demonstrations and the knowledge elicitation sessions and the list of terms constructed before and during the sessions).
- 7. A critical analysis of the experiments.
- 8. Conclusions outlining the outcome of the research project and the identification of areas of future work.

1.7. Resources

For the purposes of the research the following resources were required:

- 1. Video recording equipment
- 2. Video editing software
- 3. A laptop

1.8. Scope and Limitations

This dissertation is focused on the elicitation of a subject matter expert from a martial arts organisation, Team Ryano in Baldoyle. The knowledge elicited from the subject matter expert is limited to two fundamentally different martial art techniques used in the field.

1.9. Organisation of Dissertation

This dissertation is organised into the following chapters:

• Chapter 2: Knowledge Management

In this chapter the reader will be introduced to the concept of knowledge. This will be followed by an examination of knowledge within an organisation. Models of knowledge creation at an individual and organisational level will be introduced learning. This section will then be concluded by an overview of knowledge management and the various models which exist within the field.

• Chapter 3: Knowledge Acquisition and Elicitation

The following chapter will start with an overview of the field of knowledge acquisition. From this, an in-depth examination of knowledge elicitation will highlight the issues that exist as well as identifying the necessary requirements for such successful elicitation. This chapter will be concluded with an overview of the methods that exist.

• Chapter 4: Mixed Martial Arts

This chapter serves as a means to introduce the reader into the field of mixed martial arts from its inception, both at an international and national level. The chapter will then focus on providing an overview of the Team Ryano, highlighting the areas in which knowledge is used by the organisation. • Chapter 5: Experimental Design

The basis for the experimental design will be introduced focusing on considerations and requirements identified in the literature review. Based on these findings, the reader will introduced to the methodology that will be used to conduct the experiments.

• Chapter 6: Experiments and Evaluations

This chapter starts will as detailed account of the implementation and results from the experiments. From this, both the results and the overall methodology used will be critically analysed.

• Chapter 7: Conclusions

In the final chapter, conclusions will be made based on the outcomes of the research and details to future work will be proposed.

2. KNOWLEDGE MANAGEMENT

"Knowledge Management is the collection of processes that govern the creation, dissemination, and utilization of knowledge. In one form or another, knowledge management has been around for a very long time. Practitioners have included philosophers, priests, teachers, politicians, scribes, librarians, etc. So if Knowledge Management is such an ageless and broad topic what role does it serves in today's Information Age? These processes exist whether we acknowledge them or not and they have a profound effect on the decisions we make and the actions we take, both of which are enabled by knowledge of some type. If this is the case, and we agree that many of our decisions and actions have profound and long lasting effects, it makes sense to recognize and understand the processes that effect our actions and decisions and, where possible, take steps to improve the quality of these processes and in turn improve the quality of those actions and decisions for which we are responsible."

Brian Newman

2.1 Introduction

With the goal of extracting meaningful insights from a Subject Matter Expert (SME), it is important to fully understand the fundamental theoretical concepts that underlie this activity. This endeavour is ingrained in the realm of Knowledge Management (KM). The following chapter aims to examine the body of knowledge which underpins KM. In the first section (2.2), we will examine exactly what we are trying to extract from our SME; Knowledge. Here we will define knowledge by examining the definitions that exist in literature as well as differentiating it from other cognitive representations through the comparison of its characteristics. We will look at where knowledge resides in terms of an organisation and how it is acquired. Once defined, section 2.3 will examine the subject of Knowledge Management (KM). In this we will see how knowledge can be systematically managed for the benefit of the organisation. We will

look at the various models that exist in the field as well as the various processes required for successful implementation of KM initiatives.

2.2 Knowledge

When attempting to gain insights from a subject matter expert (SME), it is important to focus on cognitive elements which are of high value. For us, this is knowledge. So what is knowledge? This is a question which has been argued by early philosophers' through to the modern times. The classical epistemological definition, that knowledge is *"absolute true belief"*. Whilst succinct, definitions in KM literature provide a more elaborate definition of the subject. In Section 2.2.1, we will look at the various definitions as well as provide an understanding of how knowledge differs other cognitive elements i.e. data, information and wisdom. Section 2.2.2 looks at the various categorisations of knowledge that exist in KM literature. We will then look at where knowledge resides in terms of the organisation in section 2.2.3. Section 2.2.4 will conclude this section with a discussion of various models of knowledge creation which already exists in KM literature both from the perspective of the individual through to organisation knowledge creation.

2.2.1 Data, Information, Knowledge and Wisdom

To define Knowledge, we must distinguish it from other forms of cognitive elements. A model used to illustrate this is the Data, Information, Knowledge and Wisdom Hierarchy (DIKW), illustrated in figure 2.1. This model is used to discuss the relationship between each element. It is important to note, that several extensions to the model to include enlightenment and existence (Ackoff, 1989; Matthews, 1998). However in terms of the KM literature, these extended categorisations have rarely been discussed.

As we see from the DIKW model, the fundamental building block of the pyramid is the concept of data. Data represents the basic building block in creating the higher cognitive representations. In figure 2.1, we see that Liebowitz uses Davenport and Prusak's definition of data in which he defines data as a set of "*discrete objective facts about an event*" (Davenport and Prusak, 1998; Liebowitz, 2003). Awad and Ghaziri extend this definition by stating that data is static, unorganised and unprocessed (Awad and Ghaziri, 2004).



Figure 2.1 Data, Information, Knowledge and Wisdom Hierarchy

(Liebowitz, 2003)

Moving up the pyramid is the concept of Information. Liebowitz once again uses Davenport and Prusak's definition of information as "*a message meant to change the receiver's perception*" (Davenport and Prusak, 1998; Liebowitz, 2003). Awad & Ghaziri (2004) and Nonaka & Takeuchi (1995) both relate information to data in that information is seen as data that has been processed to add context, relevance and purpose. It is important to note that information is not simply a collection of data (Fleming, 1996). Table 2.1 details five mechanisms, identified by Davenport and Prusak, in which is achieved through contextualisation, categorisation, calculation, correction, and condensation of data (Davenport and Prusak, 1998).

Method	Description	
Contextualisation	The purpose or reason for collecting the data in the first place is known or understood	
Categorisation	The process of assigning a type or category to data	
Calculation	Numerical data that is processed and aggregated in order to provide useful information	
Correction	The process for removal of errors	
Condensation	Items of data are summarised into a more concise form and unnecessary depth is eliminated	

Table 2.1 Data to Information Conversion Mechanisms

In Liebowitz's DIKW model, Knowledge is defined as "*experience, values, context applied to messages*". The definition is important as KM has been criticised by some critics for not making this distinction clear. From example, Wilson (2000) noted how organisations have simple rebranded existing information systems as knowledge systems. He uses the example of the World Banks web-based Knowledge Services which was previously known as its Information Services (Wilson 2002).

Definitions of knowledge in KM literature provide an insight into the various points of view in the field. Although not exhaustive, the following are a selection of definitions which are representative of the body of knowledge in the KM.

"Justified true belief", Nonaka and Takeuchi, 1995

The first definition, by Nonaka and Takeuchi (1995), finds its roots in classical epistemological theory of knowledge. In this definition, the theory states that if something is believed, and we have a justification for believing it, and it is true, then this belief we have can be considered as knowledge. KM literature expands this

definition by providing various perspectives on the concept of Knowledge. The next definition is provided by Davenport and Prusak (1998).

"A fluid mix of framed experience, values, contextual information, and expert insight that provides a framework for evaluating and incorporating new experiences and information", Davenport and Prusak, 1998

In this definition, they identify several key components of knowledge. The first of which is Experience. This is knowledge that has been developed over time through the accumulation of lessons learnt from its application in the real world. This historical perspective provides a framework whereby new situations and events can be easily understood. The second component is values. These represent the personal beliefs of the individual that are integral to the framework for which knowledge is used. Thirdly, contextual information is the notion of an expert's knowledge is specifically focused on a specific domain of knowledge. Finally, expert insights relate to the tools used by experts such as rules of thumb and intuition in order to deduce actions from information without the need to build an answer from scratch every time. In their definition, these components facilitate new information to be considered and embedded into the working knowledge of an expert.

"Knowledge can practically be defined as a capacity to act" Hussi (2004)

In Hussi's definition (2004) of knowledge, he makes reference to knowledge and its practical application. In this sense, knowledge in its highest value form, is seen as actionable and therefore can be directly applied to the decision making process; thus making it highly desirable.

"Facts, perspectives, concepts, mental reference models, truths and beliefs, judgments and expectations, methodologies, and know-how. Understanding how to create new meanings out of isolated information." Wiig, 1993 Wiig's (1993) definition of knowledge considers an all encompassing list of knowledge components as well as a sense making activity required to create new knowledge.

In accordance with the DIKW model, four mechanisms are identified to facilitate the transformation of information into knowledge as illustrated in Table 2.2 (Davenport and Prusak, 1998). The interplay between all for mechanisms is the basis for the decision making process. A combination of information, instincts, rules, ideas, procedures and experience which guide actions and decisions.

Method	Description	
Comparison The process of being able to critically compare pieces of information		
Connection	Understanding how different pieces of information relate to other information entities	
Conversation	The ability to understand other peoples view on information	
Consequences	The understanding of implications of information	

Table 2.2 Information to Knowledge Conversion Mechanisms

Completing the DIKW model is wisdom. It has been defined as the accumulation of knowledge that encompasses vision, foresight, critical thinking and the transferring of knowledge to different contexts (Rowley, 2007; Awad *et al.*, 2004). The Leibowitz model defines wisdom as the "*collective application of knowledge in action*" (Leibowitz, 2003). However this definition somewhat blurs the distinction between wisdom and Hussi's definition of knowledge "*as a capacity to act*". In truth, the concept of wisdom has not been widely adopted in KM literature (Rowley, 2007), as most authors, in KM, prefer to use a simplified DIK model whereby the attributes of wisdom are simply embedded in the concept of knowledge (Davenport *et al.*, 1998). From this, it appears that the distinction is not as important.



Figure 2.2 Simplified Data, Information and Knowledge Pyramid (Zimmermann *et al.*, 2003)

2.2.2 Categories of Knowledge

There have been frequent attempts to systematically classify knowledge. These models have found their roots in various disciplines (such as cognitive psychology, management science, sociology, *etc*). It has been argued that these classifications have been contrived by the function in which they attempt to fulfil (Gott, 1989). While it is not the goal of this research to differentiate all categorisations, it is important to identify the ones which are common in Knowledge Management. The following section will look at three prevalent categorisations Nonaka & Takeuchi's tacit and explicit knowledge classification, Bennet's Depth of Knowledge Taxonomy, and Awad & Ghaziri's procedural, declarative, semantic and episodic knowledge.

2.2.2.1 Tacit And Explicit Knowledge

Perhaps no classification has been as widely discussed, in terms of KM literature, as the discrete categorisation of Explicit and Tacit Knowledge that was proposed by Nonaka & Takeuchi in their seminal work, The Knowledge-Creating Company (Nonaka & Takeuchi, 1995).

Using the term coined by Hungarian medical scientist Michael Polanyi, they defined *Tacit Knowledge* as the knowledge which is embedded in the minds of people (Polanyi 1967). Tacit knowledge is comprised of intuitions, values and beliefs that have been built up from years of experience. Characteristically, this type of knowledge is often difficult to articulate, represent, capture or transfer; however its value lies in its ability to be repeatedly demonstrated in contexts as varied as factory floors, research laboratories, executive boardrooms as well as our everyday lives (Crowley, 2000).

The next category of knowledge, Nonaka and Takeuchi (1995) make reference to is *Explicit Knowledge*. This can be defined as knowledge that has been precisely and formally derived from Tacit Knowledge. Once articulated, this type of knowledge can then be structured and codified in formats such as product specifications, scientific formulas and computer programs, thus allowing it to be easily distributed (Nonaka & Takeuchi, 1995). As with Tacit Knowledge, all components of knowledge can be represented. This form of knowledge is limited, in that it is context specific and can date very quickly (Awad and Ghaziri, 2004). In order for this knowledge to be of value, efforts must be made to keep it up to date, thus making it relevant to the people, in which, they aim to serve.

2.2.2.2Depth of Knowledge

Another classification of knowledge is the depth of knowledge. Bennet's taxonomy identifies three distinct types of knowledge, Surface Knowledge, Shallow Knowledge and Deep Knowledge (Bennet *et al.*, 2008).

Surface knowledge is primarily used to answer everyday questions of what, when, where and who. Knowledge in this category refers to explicit facts and represents visible choices without the need for deep understanding of purpose and underlying meaning. An example of surface of knowledge would be the case of a student studying for an examination at a surface level. Whilst this type of knowledge might suffice in

answering questions in multiple choice and those which requiring short answers, in answering essay type questions, their depth of knowledge could be easily exposed. To successfully answer these types of question, a deeper knowledge would be required. Surface-level knowledge is characteristic of an individual's ability to simply memorise facts whereby understanding of a subject is avoided and learning is achieved through trial and error. The lack of critical thinking means that this knowledge cannot be easily applied to other problems (De Jong & Ferguson-Hessler, 1996).

Deeper contextual understanding is required for *Shallow Knowledge*. Bennet defines this as surface knowledge with some additional situational awareness, semantic meaning and sense-making (Bennet *et al.*, 2008). An example of this would be the functional knowledge of the steps required to perform a technique in MMA by a novice in the field. This would typically involve situations, whereby the technique could be successfully performed with the application of a few basic rules, without the need for assistance from an expert. However in atypical situations, whereby a more complex set of rules are required to perform the technique based on the assessment of risk involved, would require a deeper knowledge of the problem.

Deep knowledge expands the notion of shallow knowledge in which the individual develops deeper understanding and meaning. Individuals achieve this state of understanding through various means. One such way is through experience which results in the creation of a rich personal archive of knowledge that is representative of an individual's perception of a problem domain (i.e. the entire area of knowledge in which a problem is defined). This archive allows an individual to thoroughly process, structure, and store new knowledge in such a way that it can be applied to variety of new complex tasks. Deep knowledge allows individuals to make critical judgments intuitively, foresee future events based on existing variables, apply best practices and theories in the decision making process, detect and use patterns of behaviour as well as provide the basis for creative thinking (Bennet *et al.*, 2008).

2.2.2.3 Procedural, Declarative, Semantic and Episodic Knowledge

The final classification of knowledge is Awad & Ghaziri's (2004) distinction between Procedural, Declarative, Semantic and Episodic Knowledge. The first type is *Procedural Knowledge*. It is the knowledge contained in the application of a procedure. This knowledge is constructed through a continual cycle of performing a specific process to the point where an individual does not consciously need to critically examine each specific task embedded in the process (e.g. clutch control in driving a car). Although procedural knowledge is often tacit this is not always the case. The knowledge required to perform a throw in judo is procedural in nature however the difficulties to articulate in words given our limited understanding of laws of motion and balance would be indicative of tacit knowledge. On the other hand, the procedural knowledge required baking a cake would be explicitly available in well-known recipes (Freeman, 2001).

Declarative Knowledge is defined by Awad and Ghaziri as an awareness of knowledge. This knowledge provides a point of reference that can be used in discussion. It be expressed in terms of declarative statements and indicative propositions and is therefore explicit in nature. This type of knowledge can vary from the characteristics of shallow knowledge (section 2.2.2.2), in that it is readily recalled and synonymous with the type of knowledge held in short term memory (i.e. the part of the brain which stores information for a short period of time), to deep knowledge, whereby atypical facts from experience can be represented in long term memory. An example of this type of knowledge would the knowledge that would be required to retain a number when waiting in line for a doctor in a hospital.

The next category of knowledge is *Semantic Knowledge*. Semantic knowledge refers to the abstract rules and concepts that have been constructed over our life time relevant to the way in which we view the world. This knowledge is highly organised and exists in long-term memory. Gained over a large period of time from our experiences, it is related to our knowledge of concepts, vocabulary, facts, and relationships. An example from the field of MMA would be in the knowledge used to describe terms to express concepts in the field e.g. the difference between a single leg takedown and a double leg takedown.

The final category is *Episodic Knowledge*. This knowledge is based on events that are observed through experience (Nuxoll and Laird, 2004). This can range from a simple snapshot from one's past experience to more complex episodes that can be compared to entire reels of footage stored within an individual's mind. As with Semantic Knowledge, this type of knowledge resides in long-term memory. The most distinctive feature of episodic knowledge is that the individual sees themselves as an actor within the events (Awad and Ghaziri, 2004). This type of knowledge is of high value as it not only contains knowledge about the events themselves but also reveals more about the entire context in which it was used.

2.2.2.4 Combining Categorisations Of Knowledge

In terms of the literature, the various means of classifications used in 2.2.2.1, 2.2.2., and 2.2.2.3, are not used discretely. In an attempt to bring these categorisations together, this section looks at how our categorisations can be combined. With reference to examples from the field of MMA, we will illustrate how these categorisations do not simply exist as discrete entities but in fact co-exist and are in fact highly interoperable.

In table 2.3, we compare the various components used in Bennet's taxonomy with those used in the Nonaka's categorisation of tacit and explicit knowledge. In this comparison, we can see that tacit and explicit knowledge can vary in terms of the depth of knowledge which is contained within. An example would be the necessary understanding of how to perform an MMA technique; at a deep level the expert is able to demonstrate the move in reference to typical and atypical situations. A video recording of this demonstration would provide an example of explicit knowledge at a deep level.

In table 2.4, we can compare the various components used in Awad and Ghaziri's categorisation of declarative, procedural, semantic and episodic knowledge with those used in the Nonaka's categorisation of tacit and explicit knowledge. In this we see that declarative, procedural, semantic and episodic knowledge can reside tacitly or explicitly codified in documents. An example of this would be at an episodic level

whereby fighter has first hand experience pertaining to their decision making processes during a fight, this account could be documented in an article and thus made explicit.

	Surface	Shallow	Deep
Tacit	An individual's	An individual's knowledge	A fighters first hand
	knowledge of an	of steps involved	account pertaining to
	MMA fighter's win /	performing a technique in	their decision making
	loss record.	MMA	processes during a fight.
Explicit	Statistics found in	An instructional video	Accounts, published in
	online tools where	demonstrating the steps	books, pertaining to a
	facts, pertaining to a	involved performing a	fighters decision making
	fighter's win / loss	technique in MMA	processes during a fight.
	record, are recorded.		

Table 2.3 Comparison of Bennet's taxonomy and Nonaka's Categorisation

	Declarative	Procedural	Semantic	Episodic
Tacit	An individual's	An individual's	An	A fighters first
	knowledge of an	knowledge of the	individual's	hand experience
	MMA fighter's	steps involved in	understanding	pertaining to
	win / loss record.	performing a	of variations	their decision
		technique in MMA	of terms in	making
		(e.g. a takedown, a	MMA (e.g. a	processes during
		submission, etc).	double leg	a fight.
			takedown, a	
			single leg take	
			down, etc.)	
Explicit	Statistics found	An instructional	Online	Accounts,
	in online tools	video demonstrating	glossaries of	published in
	where facts,	the steps involved in	detailing the	books,
	pertaining to an	performing a	variations of	pertaining to a
	MMA fighter's	technique in MMA	terms in	fighters decision
	win / loss record,	(e.g. a takedown, a	MMA (e.g. a	making
	are recorded.	submission, etc.).	double leg	processes during
			takedown, a	a fight.
			single leg take	
			down, etc.)	

 Table 2.4 Comparison of Nonaka's Categorisation and Awad & Ghaziri's Categorisation

The final comparison, in table 2.5, makes reference to the knowledge components found in Bennet's taxonomy and Awad and Ghazari's categorisation of knowledge. In this we see that knowledge declarative, procedural, semantic and episodic knowledge can also differ in its granularity. An example from table 2.5, are the facts pertaining to a fighter's win / loss record. Whilst this might be useful, it is characteristic of surface knowledge. However the declarative knowledge, required to identify top fighters in the different weight divisions, requires access to a larger set of statistics which would be characteristic of deep knowledge.

	Declarative	Procedural	Semantic	Episodic
Surface	The facts	An awareness of	Basic	Basic
	pertaining to a	the steps	understanding of	recollection of a
	fighter's win /	involved in	terms in MMA	fight
	loss record.	performing a	(e.g. a punch, a	
		technique in	kick, a	
		ММА	takedown, etc.)	
Shallow	Putting into	Functional	An	First Hand
	context the	knowledge of the	understanding of	accounts
	significance of a	steps required to	variations of	pertaining to a
	fighter's win,	performing a	terms in MMA	fighters decision
	given the record	technique in	(e.g. a double leg	making
	of their	MMA (e.g. a	takedown, a	processes during
	opponent's	takedown, a	single leg take	a fight.
	record.	submission, etc.).	down, etc.)	
Deep	Being able to	In-depth	Strategic	A fighter's
	identify the top	granularity of	understanding of	collective
	fighters in the	the steps	when techniques	experiences of
	different weight	involved in	should be used	fights and the
	divisions.	performing an	and the potential	lessons learnt
		MMA efficiently	consequences	from
		given the	associated with	participation
		contextual	failure of	against a variety
		environmental	perform the	of opponents
		signals.	techniques	from a variety of
			correctly.	backgrounds.

Table 2.5 Comparison of Bennet's Taxonomy and Awad & Ghaziri's Categorisation

In conclusion, whilst the various categorisations of knowledge are an important component in describing the various characteristics of knowledge, it is necessary to combine these characteristics in order to gain a deeper understanding of knowledge.

2.2.3 Knowledge in Organisations

Knowledge exists in all of an organisation's operational units. This can range from superficial knowledge, required to login into a companies system, to the deep working knowledge required to be competitive in the organisations field of business. In order to understand the nature of organisational knowledge, the following section will look at four entities where organisational knowledge resides. In section 2.2.3.1, we will review the role of individuals, employed by an organisation. When these individuals work in collaboration with others, they work as as a group. In section 2.2.3.2, we will look at this dimension, its characteristics, and its importance to the organisations. A greater dimension in organisational knowledge is when all the teams within an organisation work together. Section 2.2.3.3 provides a discussion of the organisational level dimension. And finally, in section 2.2.3.4 will discuss the extra-organisational element, in which external factors influence organisational knowledge.

2.2.3.1Individuals

At the start of what was known as the Information Age, organisations invested heavily in a technological infrastructure that out performed people in terms of their ability to perform complex calculations, transmit and recall vast amounts of data over distances at speeds higher and accuracy than were ever thought previously possible. However these systems lacked the abilities to innovate. Quinn stated that 'Ideas and intellect, not physical assets, build great companies' (Quinn, 1992). Thinking and invention, however, are the assets upon which knowledge work and knowledge companies depend (Stewart, 1997). The success or failure of their organisations rests firmly on the shoulders of its employees; hence the recurring mantra used by C.E.O.'s worldwide, that people are a company's most valuable asset.
New knowledge always starts with the individual. The term "*Knowledge Worker*" coined by Peter Drucker (1959), in which he defined a knowledge worker as "*one who works primarily with information or one who develops and uses knowledge in the workplace*". Although the value of this statement was not immediately recognised, authors later used this as the basis for what is now known as knowledge management. This notion signalled the shift from the mechanical use of individuals to one where workers were encouraged to use their knowledge, in more thinking-oriented work. As a consequence, workers with deep knowledge of organisational operations were encouraged to look at these functions with a critical eye and embed their knowledge to advance their processes, products, services and initiatives. The value of these individuals has not gone unnoticed by organisations, as they continually look for ways in which this knowledge might be retained, due to individuals retiring or leaving the company.

These individuals possess what is known as domain specific knowledge. Huntington defines this specialised knowledge as "*expertise*" (Huntington, 1957). Individuals vary in terms of the depth of expertise. Those who possess a high level of expertise are often referred to as "*experts*" whilst those who possess a low level are known as "*novices*". In figure 2.3, we see how expert knowledge decomposed into the basic cognitive elements (identified in section 2.2.1).

In looking at the characteristics of expertise, Chi (2006) indentified eight ways in which in which an expert's knowledge excels from that of novice (Table 2.6). These characteristics are the ones which are held in the highest regard by organisations seeking to improve processes and develop new and innovative products. Whilst the characteristics of an expert are important, Chi (ibid) also identified ways in which an expert's knowledge is limited (see table 2.7). To get the most out of these experts, organisations must seek ways in which expertise can be effectively managed.



Figure 2.3 Data to Expert Conversion

Best Practices	"Experts excel in generating the best solution even under time
	constraints, or the best solution in solving problems, or the best design in
	a designing task. Moreover, they can do this faster and more accurately
	than non-experts"
Detection And Recognition	"Experts can detect and see features that novices cannot They can also
	perceive the "deep structure" of a problem or situation"
Qualitative Analyses	"Experts spend a relatively great deal of time analyzing a problem
	qualitatively, developing a problem representation by adding many
	domain-specific and general constraints to the problems in their domains
	of expertise"
Monitoring	"Experts have more accurate self-monitoring skills in terms of their
	ability to detect errors and the status of their own comprehension."
Strategies	"Experts are more successful at choosing the appropriate strategies to
	use than novices."
Opportunistic	"Experts are more opportunistic than novices; they make use of whatever
	sources of information are available while solving problems and also
	exhibit more opportunism in using resources."
Cognitive Effort	"Experts can retrieve relevant domain knowledge and strategies with
	minimal cognitive effort They can also execute their skills with greater
	automaticity and are able to exert greater cognitive control over those
	aspects of performance where control is desirable"

Table 2.6 Ways in which Expert's knowledge excel's from that of a Novice

Domain-Limited	"Expertise is domain-limited. Experts do not excel in recall for domains
	in which they have no expertise."
Overly Confident	"Experts can also miscalibrate their capabilities by being overly
	confident."
Glossing Over	"Although experts surpass novices in under-standing and remembering
	the deep structure of a problem, a situation, or a computer program,
	sometimes experts fail to recall the surface features and overlook details."
inflexible	"Experts have trouble adapting to changes in problems that have a
	deep structure that deviates from those that are "acceptable" in the
	domain."
inaccurate prediction, judgment,	"Sometimes they are inaccurate in their prediction of novice
and advice	performance."
	"In tasks requiring decision under uncertainty, such as evaluating
	applicants for medical internships or predicting successes in graduate
	school, it has been shown consistently that experts fail to make better
	judgments than novices. Such lack of superior decision making may be
	limited to domains that involve predicting human behaviour, such as
	parole decisions, psychiatric judgment, and graduate school successes."
bias and functional fixedness	"Bias is probably one of the most serious handicaps of experts"
	"Greater domain knowledge can also be deleterious by creating mental
	set or functional fixedness. In a problem-solving context, there is some
	suggestion that the more knowledgeable participants exhibit more
	functional fixedness in that they have more difficulty coming up with
	creative solutions."

Table 2.7 Ways in which Expert's knowledge falls short of a Novice's Knowledge

To identify and categorise expertise, organisations use techniques such as proficiency scales. Table 2.8 illustrates an example of a proficiency scale created by Hoffman (1998) in which he categorises individuals into groupings based on the knowledge levels they possess. Hoffman's scale ranges from the level of non-experts (novices) through to the highest level of proficiency, master level. The scale is useful in that it provides a clear path for individuals to rise through the ranks in order to achieve master status. To assess proficiency levels, various means can be employed. In terms of an MMA organisation, this is usually achieved by measures such seniority, years performing the art, or a consensus opinion formed amongst its peers. Traditional Martial Arts use a belt system in which the knowledge of students can be measured in

terms of domain-specific knowledge. The use of performance testing, and the various belts associated with test, provides the novice with the path to the goal of black belt, seen as the end-all symbol in martial art style competency.

Naive	One who is totally ignorant of a domain
Novice	Literally, someone who is new – a probationary member. There has been some minimal exposure to the domain.
Initiate	Literally, a novice who has been through an initiation ceremony and has begun introductory instruction.
Apprentice	Literally, one who is learning – a student undergoing a program of instruction beyond the introductory level. Traditionally, the apprentice is immersed in the domain by living with and assisting someone at a higher level. The length of an apprenticeship depends on the domain, ranging from about one to 12 years in the Craft Guilds.
Journeyman	Literally, a person who can perform a day's labor unsupervised, although working under orders. An experienced and reliable worker, or one who has achieved a level of competence. Despite high levels of motivation, it is possible to remain at this proficiency level for life.
Expert	The distinguished or brilliant journeyman, highly regarded by peers, whose judgments are uncommonly accurate and reliable, whose performance shows consummate skill and economy of effort, and who can deal effectively with certain types of rare or "tough" cases. Also, an expert is one who has special skills or knowledge derived from extensive experience with subdomains.
Master	Traditionally, a master is any journeyman or expert who is also qualified to teach those at a lower level. Traditionally, a master is one of an elite group of experts whose judgments set the regulations, standards, or ideals. Also, a master can be that expert who is regarded by the other experts as being "the" expert, or the "real" expert, especially with regard to sub-domain knowledge.

Table 2.4 Proficiency scale of Individuals

(Hoffman, 1998)

In terms of the knowledge various categories indentified in section 2.2.2, we can see that individual knowledge can comprised of all three forms. As discussed in section 2.2.2.1, tacit knowledge resides in the mind of the individual. In terms of an individual, explicit knowledge artefacts can be located physically (e.g. hard copied documents in books, papers, filing cabinets, inboxes) or digitally (e.g. files located on hard disks). As opposed to tacit knowledge, explicit knowledge artefacts can be easily managed. Explicit knowledge is of great value within an organisation as it can easily be detached from its owner and distributed for processing at the group, organisational or extraorganisational level (Bratianu, Jianu *et al.*, 2006, pp.169-172). However it is important to note that individual level of knowledge, belonging to each member of the organisation, can be released only by the individual. A company's competitive

advantage is not only dependent on its distinctive intangible resources but also on its capability to exploit those resources effectively (Nelson and Winter, 1982, in Riege, 2007). As a means of facilitating this transfer, organisations use various methods such as compensation programs, performance reviews, fostering co-operative cultures, *etc*.

2.2.3.2 Group Knowledge

As important as individual knowledge is to an organisation, the creation of new knowledge only occurs when knowledge is shared (Hall, 2001). One mechanism, an organisation provides in order to achieve this, is through the creation of groups or *communities of practice*. A group can be defined as 'a dynamic whole based on interdependence rather on similarity' (Lewin, 1951). Groups exist, either formally or informally, in order to discuss issues for which the participants share a common understanding and interest (Wenger, 2006). In organisations, these communities of practice, often bridge departmental barriers, providing a mechanism for organisational collaboration. A precondition for the assembling of these groups is to make sure that all the relevant stakeholders in the organisation have been identified in order to contribute to area of interest. This is crucial as having the right people involved enables an increased perception of ideas from the different perspective which therefore stimulates creativity and has a positive effect on overall activities of the group (Rüdiger and Vanini, 1998).

Once a group has been established, there are various methods, both natural and contrived, which can be employed to identify and create group knowledge (e.g. brainstorming, discussion boards, scrum meetings, *etc.*). Knowledge can reside both tacitly within the individuals of the group or explicitly in the associated common repositories created in order to support the collaboration process. While group knowledge is shared, it generally remains within the context of the community of practice. We see as these groups mature, the depth of group knowledge increases. Individuals become aware of the strengths and weaknesses of their fellow group members; they understand each other's approaches; they recognise what needs to be communicated and what can be taken for granted (Skyrme, 2000). In defining group

knowledge, it is not simply the aggregation of the individual interpretations, but the synthesis of interpretations (Richter, 2000).

Within a mixed martial arts organisation, such as the subject of our study Team Ryano, various groups exist. One group focuses on the grappling arts (i.e. Judo, Brazilian Jiu-Jitsu (BJJ) and Submission Wrestling). In isolation, this group uses sport specific coaching staff to focus, primarily, on the preparation of its fighters to perform in national and international competitions in fields of Judo, BJJ and Submission Wrestling. Whilst others groups within Team Ryano, focus on the striking arts such as Boxing and Thai-boxing, again in preparation for competition at national and international level.

2.2.3.3Organisational Knowledge

Organisation knowledge has been defined as a "*resource consisting of the sum of what is known in the organisation*" (Holesapple, 1996). It is embodied in the primary and supporting functions of an organisation, its inter-organisational processes, as well as the beliefs and behaviour which infuse an organisation (Nelson and Winter, 1982). Knowledge is increasingly becoming acknowledged as a key corporate asset. In fact, it has been argued that organisational knowledge has superseded traditional factors of production (i.e. land, labour and capital) as the most important corporate and competitive resource in today's economy (Havens and Knapp, 1999).

Organisational knowledge can reside both tacitly and explicitly. It differs from that of its group counterpart. Where as tacit knowledge in a group is built on the formal relationships between its members who share a common interest, tacit knowledge within an organisation is built on relationships that exist because of organisational structure. As individuals within these departments leave, they are replaced by new colleagues, who inherit some, but not all, of the knowledge acquired by their predecessors. This knowledge is contextually specific to the department and is not often found freely available in technical publications. Elicitation of this knowledge often requires exposure to a department's processes, best practices and relationships within the unit. As well as the tacit knowledge, knowledge resides explicitly in the technological infrastructure provided by the organisation as well as physically in filing cabinets and corporate libraries. As well as the everyday data and information processing requirements, organisations have begun to invest in technologies, such as knowledge repositories. They are used to retain knowledge artefacts about its organisational processes and provide a mechanism that creates a symbolic link between knowledge and other related artefacts (Becerra-Fernandez, Gonzalez & Sabherwal, 2004).

Organisational knowledge creates a common culture that can be used crossfunctionally; thus providing a language that allows groups to interact. This interaction allows organisations to expand the depth of organisational knowledge by reconstructing existing perspectives, frameworks, or premises on a day-to-day basis (Nonaka, 1994). However when organisations do not have the knowledge required to gain a competitive advantage, a common strategy is to look outside of the organisation and incorporate extra-organisational knowledge into the organisational knowledge.

In terms of organisational knowledge, Team Ryano uses the knowledge from the various groups in order to prepare its fighters for mixed martial arts competitions. Coaches and fighters to interact with the diverse groups in order the synergise concepts and, often conflicting, strategies from each art, in order to successfully apply them to the sport of mixed martial arts.

2.2.3.4Extra-Organisational Knowledge

Another component of an organisation's knowledge is the knowledge that is stored in its relationships with external entities. The primary relationships are the ones associated with customers and suppliers in which knowledge is created and ingrained (Becerra-Fernandez, Gonzalez & Sabherwal, 2004). Secondary relationships also exist in communities of practice that extend beyond organisational boundaries, as opposed to the internal communities discussed in section 2.2.3.2. These communities' relationships exist by what they do rather than where and for whom they work for (Cohen, 2006). Professional organisations or societies maintain forums and hold conferences on topics of interest that helps facilitate the transfer of deep tacit and explicit knowledge about the industry which an organisation works within. They also publish journals on shared topics of interest and offer consultancy as a means of sharing extra-organisational knowledge.

There are significant benefits to be gained from the use of external entities. Extraorganisational knowledge is a valuable source, particularly if a knowledge gap exists within an organisation's internal knowledge base. This knowledge can fill deficits and add value to overall organisational knowledge (Cohen, 2006). Having multiple perspectives on potential solutions provides an organisation greater accessibility to needed knowledge as well as a means to generate a greater number of alternative solutions for review (Constant et al. 1996; Granovetter, 1973). Menon and Pfeffer (2003) suggest that an organisation is more likely to value knowledge from external entities rather than the knowledge that resides internally. Their study identified two major reasons for this. The first was due to the status implications of learning from internal versus external competitors. They argue that organisations are often an arena where competition for promotions, status, and salaries occurs. As a result, there is little to be gained in the way of personal self-enhancement, by legitimising ideas of a direct competitor for organisational rewards. This apprehension was seen to motivate managers to learn from external entities for fear of being out-competed in the internal marketplace. The second reason is the scarcity of knowledge in the organisation. Even though internal knowledge is more readily available, it is subject to greater scrutiny. External knowledge is scarce, which makes it appear more special and unique. Managers often value the analysis of consultants, whose claims of expertise and objectivity can dominate the recommendations of internal competitors, even when they both say the same thing. Favouring external entities and consultants, and ignoring good internal ideas can be detrimental to an organisations business activity. This was no more evident in the instance of Xerox in the 1970s, where the managers concentrated their activities on the work being done by external competitors (Jacobsen and Hillkirk, 1986). In doing so, they failed to introduce product innovations developed at its own research facilities, Xerox's Palo Alto Research Centre (PARC). Innovations such as the personal computer, the mouse, and word processing software, were all later commercialised and profited by other companies (Smith and Alexander, 1988).

From an intra-organisational level, Team Ryano have actively engaged in Irish and International communities of practice such as the Irish based boards MMA forum (www.boards.ie), the UK based Cage Warriors forum (www.cagewarriors.com) and US based Sherdog forum (www.sherdog.com) in the proliferation of ideas and best practices. Affiliation to international organisations, such the Brazilian based organisation Revolution BJJ as (www.revolutionbjj.com) has validated the level of its athletes in relation to their internationally respected BJJ belt system. This affiliation also proved fruitful as it has provided Team Ryano with direct access to masters in the field of BJJ, in the form of seminars conducted by Rodrigo Medeiros, Carley Gracie and Ryan Gracie. Its active participation in MMA competitions has also seen the building of good relationships with MMA organisations such as the (now defunct) UK based Cage Rage Organisation. This collaboration enabled Team Ryano and SBG Ireland to organise one of the largest MMA events (Cage Rage Contenders) in the history of Irish MMA.

2.3 Organisational Learning

To succeed in business, an organisation must constantly create new knowledge in order to add value to its products and services. According to Senge (1991) individual learning by itself does not ensure organisational learning. However he argues that without individual learning no organisational learning occurs. Therefore it is essential that organisations support and facilitate individual learning and knowledge creation. There is a plethora of research which has been undertaken on the subject of knowledge creation. For the purpose of this review, three models have been selected: Vygotsky's Apprenticeship model; the work of Choo's and his Organisational Knowing Cycle (OKC); and finally Nonaka and the SECI model.

2.3.1 The Apprenticeship Model of Learning

Derived from constructivism, the first model of knowledge creation we will examine is the apprenticeship model (Vygotsky, 1978). In this work, Vygotsky identified three processes, required for a master of a skill to teach that skill to an apprentice, observation, coaching and practice.

The observation activity is a process whereby a novice observes the expert as they perform the target skill. From this the novice aims to mental construct a model of how the task should be performed. Once a mental model has been instilled, the next step is coaching. In this task, the novice is guided through the technique under the supervision of the expert. The expert provides continuous feedback and support whilst performing target skill. As the novice's skill improves during the coaching process, the level of support diminishes. It is the responsibility of the expert to monitor the novice's competence in performing the task in respect to the level required to perform the task unassisted. This difference is known as the "zone of proximal development". Vygotsky believed that by fostering development within this zone led to the most rapid development (ibid). After the coaching activity has been performed to the required level, the novice was expected to have sufficient skill in order to carry out the task in practice in a simulated environment. The novice then performs the target skill with master present who will only offer brief pointers on specific elements of the target skill.

Vygotsky's apprenticeship model is characteristic of the models of knowledge creation seen in physical activities such as dance and martial arts. A limitation of this model is that expert often fails to expose the all the elements of knowledge implicit in the often complex process being taught to novices. As a means of addressing this, the model was later expanded to create the cognitive apprenticeship model, which addresses the teaching of cognitive and meta-cognitive skills, as opposed to purely physical skills and processes addressed by the traditional forms of the apprenticeship model (Collins *et al.*, 1989).

Whilst the model does not model the creation of knowledge at group, organisational and extra-organisational level, it is used in organisations and relevant in terms of the transfer of tacit knowledge to individuals.

2.3.2 Organisational Knowing Cycle

A model that does incorporate knowledge creation at group and organisational level is Choo's Organisational Knowing Cycle (OKC). In this, Choo believes that learning and innovation within organisations is a result of managing the activities of sense making, knowledge creation, and decision-making (Choo, 1998). Choo argues that whilst organisations value these activities in isolation, it is the dynamic relationships amongst these activities that generate the greatest potential for value (Choo, 1998).



Figure 2.4 Choo's Organisational Knowing Cycle

(Choo, 1998)

Choo uses Weick's (1979) assumption that organisational knowledge is based on the fact that people are responsible for the construction of the organisation's knowledge. When new problems, opportunities, or tasks present themselves, it is the responsibility of people within the organisation to re-align the existing organisational knowledge to cope with new complexity.

The initial step in making the necessary change is the process of Sense Making. This is the process of creating situational awareness and understanding. As the new situations arise, they are often ill-defined, iterative and complex. In order to find a solution, it is important to somehow structure the seemingly unstructured situation. Depending on the complexity of the new problem, this can extend far beyond an individuals ability to solve the problem. In such cases, groups are needed to work together, combining information from many multiple sources, in order to create a synthesised understanding of the problem which takes into account different points of view. Once this shared meaning has been established, it can be fed into the knowledge creation and decision making processes.

Directed by a knowledge vision of AS IS (the current understanding of organisational knowledge) and TO BE (the desired understanding of future organisational knowledge), Knowledge Creation is seen as a direct response to gaps in the existing organisational knowledge, realised in the Sense Making process. Such gaps can inhibit the way in which organisations solve problems, develop new products or services. Choo identifies three types of knowledge that exists with an organisation: tacit knowledge embedded in the experience and expertise of individuals; explicit knowledge codified as artefacts, rules and routines; and cultural knowledge expressed as assumptions, beliefs, and values. For new knowledge to be created this requires the conversion, sharing, and combination of all three forms. The resulting knowledge and additional competences increases an organisation's ability to extend organisational capabilities and develop new innovations.

In the decision-making process, Choo believes that the key factors in the decisionmaking process are clarity of the goal and the knowledge of actions required in order to attain the goal. Difficulties arise when goals are not clearly defined or when knowledge about solutions are not known. To illustrate this, Choo uses a twodimensional matrix in which organisational decisions are separated by goal clarity (degree to which goals are defined) and procedural certainty (degree to which solutions are known). Based on these two dimensions, Choo categorises decisions making into four discrete modes (Figure 2.5).

When goal and procedural clarity are both high, decision making follows a "Boundedly Rational Mode". In this quadrant, decisions are made by decision

premises and decision routines (March and Simon, 1993). Organisations specify decision premises that define what criteria to apply in evaluating solutions (value premises), and what information is relevant (factual premises). These premises are embedded in decision routines that structure the decision process with rules and procedures. Decision selection follows the satisfaction rule i.e. a solution is chosen that is achieves the desired goal. The decision process is simplified when the organisation has experience of resolving similar problems or when pursuing one goal at a time rather than attempting to resolve multiple goals of competing divisions within the organisation.

	Low Goal Ambiguity/Conilict	High Goal Ambiguity/ Conflict
Low Procedural Uncertainty	Boundedly Rational Mode	Political Mode
High Procedural Uncertainty	Process Mode	Anarchy Mode

Figure 2.5 Four Modes of Organisational Decision Making

(Choo, 1998)

When goals are clear but the methods to attain them are not, decision making occurs in a "*Process Mode*" (*Mintzberg et al.*, 1976). This process is divided into three phases. The "*identification phase*" clarifies the need for decision and aims to develop an understanding of the decision issues. Once established, the "*development phase*" looks

internally / externally for ready made solutions and design routines in order to build to bespoke a solution. Once a list of potential solutions has been established, the *"selection phase"* reviews the individual merits and shortcomings of each solution and selects one based on an acceptance criterion. This is a dynamic process that often requires multiple iterations.

When conflicting goals are being pursued by individuals or groups (who each have a preferred solution in place), decision making occurs in "*Political Mode*". This requires organisations to behave as coalitions in order to resolve the goal conflict (Cyert and March, 1992). Groups, within the organisation, form coalitions in order to push for preferred alternatives. To resolve goal conflict, organisations have to pursue procedural rationality over goal rationality. They achieve this by establishing forums whereby groups to present their points of view, ask questions, and move towards an acceptable solution through bargaining, negotiation and compromise.

When goals and alternatives are both unclear, decision making occurs in the "*Anarchic Mode*" (Cohen *et al.*, 1972). In this mode decision situations consisting of random streams of problems, solutions, participants, and choices, come and go. Decision making happens when problems, solutions, participants, and choices align. When they do, participants who are present at that point in time attach solutions to problems and problems to choices.

To some degree, all organisations engage in all four decision making modes. Decision making in the "boundedly rational mode" are easily resolved when access to deep organisational knowledge is available, thus reducing time and effort required. The "process mode" is a way for organisations to effectively search or design solutions in new areas of business. Organisations, that provide a forum for alternative points of view, can prevent complacency or parochialism. The "anarchic mode" provides a mechanism for organisations to discover new goals and unearth new solutions in unfamiliar territory.

2.3.3 The SECI Model

Another model which explains knowledge creation at an individual, group and organisational level is Nonaka and Takeuchi's SECI (*socialisation, externalisation, combination, and internalisation*) model. In this model, the key to knowledge creation lay in the mobilisation of tacit and explicit knowledge (see section 2.2.2.1) in a spiral like process. As the acronym suggests, the model is based on four modes of knowledge conversion, socialisation, externalisation, combination and internalisation (Figure 2.6).



Figure 2.6 Nonaka's SECI process and "Ba"

(Nonaka and Takeuchi, 1995)

The socialisation process is the transfer of tacit knowledge between individual (i.e. tacit to tacit knowledge conversion). It is a means of sharing of knowledge through face-to-face communication (Nonaka and Takeuchi, 1995). This conversion occurs when knowledge is acquired by an individual and shared without being made explicit. Mechanisms, such as conversations, team meetings, apprenticeships, and brain storming sessions, facilitate this mobilisation.

The externalisation process is the process of making an individual's tacit knowledge explicit (i.e. tacit to explicit knowledge conversion). Nonaka and Takeuchi (1995) describe this as *"articulating tacit knowledge through dialogue and reflection"*. This

conversion occurs when an individual articulates their knowledge, in such a way that it can be explicitly represented. The use of metaphor and/or analogy is a useful mechanism as a means to address its complexity. Once articulated, this knowledge can reside in a number of formats (e.g. a document, report, video presentation, *etc.*) which allow it be easily transferred to other individuals.

The combination process is as Nonaka and Takeuchi (1995) describe it as "*a combination of various elements of explicit knowledge*" (i.e. explicit to explicit knowledge conversion). This provides a mechanism whereby related knowledge artefacts can be logically combined in order to produce a well-ordered body of knowledge about a subject area. The use of technology is an excellent facilitator of this process. Tools, such as wikis, can be used to aid aggregation of the various artefacts.

The internalisation process is the process of making explicit knowledge tacit (i.e. explicit to tacit knowledge conversion). This provides a mechanism whereby new tacit knowledge can be learnt and acquired in practice (Nonaka and Takeuchi, 1995). Concepts, which have been codified and disseminated by the organisation, can be absorbed by the individuals and used in their decision making processes.

As a perquisite for successful implementation of the model, each of the SECI processes requires a working space or "Ba" to facilitate knowledge creation (Nonaka and Konno, 1998). In the socialisation process, a space termed as the "*Originating Ba*", provides a forum where knowledge can be shared through face-to-face interactions. A "*Dialoguing Ba*" space is required in the externalisation process which facilitates the articulation of mental models and skills to create a common vocabulary of terms and concepts. The combination process uses a space called "*Systemising Ba*" which provides a location for the collection and organisation of related knowledge assets through technology. And finally, the "*Exercising Ba*", a place for embodying explicit knowledge through virtual interaction, as the space required in the internalisation process.

Although individual knowledge creation can occur within each of these modes in isolation, organisational knowledge creation requires all four modes to working in a

continuous cycle (Nonaka, 1994). Figure 2.7 illustrates how organisational knowledge gradually increasing with the active participation at individual, group, organisational and inter-organisational level. From a management perspective, key people are required in all four elements to lead the knowledge creating process. These people will be responsible for the overall vision of knowledge in the organisation; developing the skills of individuals and groups, actively promoting the sharing of knowledge assets, creating and energising the required working spaces "*Ba*", and continuing the spiral of knowledge creation.



Figure 2.6: Spiral of Organisational Knowledge Creation

(Nonaka, 1994)

2.3.4 Comparison of Organisational Knowledge Models

In the literature review of knowledge models, we see that all of the models share a degree of commonality as well as a degree of conflict. It is inconceivable that an all in compassing model exists. In understanding the commonalities and the difference, the following sections will look at them in depth.

2.3.4.1 Comparing the Notion of Knowledge Creation Environment

In establishing the conditions for knowledge creation, the models share a degree of similarity. One commonality is the need to establish a common language. In the OKC model, the sense making facilitates this activity through the creation of synthesised understanding of concepts. This is implicit in the apprenticeship model, in that a common language is required for in the transfer of knowledge and essential in the SECI model in order to facilitate the mobility of knowledge.

Another commonality is the reliance on collaboration in the organisational knowledge creation process. The OKC model makes reference to collaboration in all of the sense making, knowledge creation and decision making processes. The apprenticeship model requires collaboration between the novice and the expert. While in the SECI, collaboration is a characteristic of the socialisation process.

The models differ in terms of the identification of workspaces. OKC and the apprenticeship model do not explicitly recognise the need for environmental conditions to nurture the creation of knowledge activity. Whereas, the SECI model explicitly makes reference to the creation of 'Ba' spaces for each part of the SECI processes and through the creation of joint information spaces.

2.3.4.2 Comparing the Notion of Knowledge Creation Processes

In comparing the models it is difficult to map the individual processes of each model (Table 2.1). Whilst the sense-making and the decision making from the OKC model, the socialisation from the SECI model and the observation and coaching phases of the apprenticeship model, all share commonalities, there are significant differences between the three models.

The first difference between the models lies in Choo's Sense Making process. In this, Choo makes reference to situational awareness and understanding as the first step in the knowledge creation process. We can presume that this is implicit in the socialisation process of the SECI. In terms of the observation, coaching and practice phases of the apprenticeship model, situational awareness and understanding comes as a consequence of engagement in all three phases. The OKC model illustrates the importance of this step, not only the knowledge creation phase but also in the decision making process; a phase neglected by the other two models. In the OKC model, decision making is also seen as a driver in knowledge creation.

Secondly is the use of information in the sense-making process. The SECI model and the apprenticeship model's seem to have ignored the importance of information in the creation of knowledge. Choo's inclusion of this cognitive element corresponds to the transition of the information to knowledge conversion seen in the DIKW model (in section 2.2.1).

ОКС	SECI	Apprenticeship Model
Sense Making		Observation
Decision Making	Socialisation	Coaching
		Practice
	Externalisation	
Knowledge Creation	Combination	
	Internalisation	

Table 2.5 Comparison of the Knowledge Creation Processes

The next difference is OKC model uses an all encompassing process that includes functionality from the externalisation, combination, and internalisation processes from the SECI model. The apprenticeship model is solely focused on the acquisition of tacit knowledge, and is therefore not concerned with the explicit artefacts in the creation of knowledge. In addition to tacit and explicit knowledge, OKC model identifies a third, cultural knowledge but it can be argued that this is implicit in the tacit knowledge of the other two.

Whilst the SECI and OKC models make reference to the roles individuals, groups, and organisation, the SECI model adds the extra-organisational entity into its model. The apprenticeship model is focused on one-to-one learning and is therefore only concerned with knowledge acquisition of the individual.

2.3.4.3Comparing the Management of the Knowledge Creation Processes

There is a sense in all of the models, that the individual processes by themselves create individual knowledge. However knowledge creation is a continuous cycle of all of the processes which only strengthens through continual use, creating deep organisational knowledge. The SECI model, the apprenticeship model and the OKC model make reference to the need for a Knowledge Vision. In the OKC model, this is the gap that exists between the current and the desired understanding of organisational knowledge. Nonaka sees this as an essential enabler of the SECI process. In the apprenticeship model, this is defined as the "zone of proximal development".

2.4 Knowledge Management

In order to manage the complexity of organisational knowledge, a field of study has emerged called Knowledge Management (KM). Exponents of the discipline believe this to be a principal component of the new economy in which it provides organisations, who adopt KM principles, with a competitive advantage; arguing that its importance has superseded a firms traditional factors of production (e.g. land, labour and capital) to become the most significant corporate and competitive resource (Havens and Knapp, 1999). In the section 2.4.1, we will look at the multiple definitions of KM that exist in the literature as a means of defining KM. In section 2.4.2, we will look at the challenges that face KM. In section 2.4.3, we will look at the various models that exist in KM. In section 2.4.4, we will look at the knowledge processes.

2.4.1 Defining Knowledge Management

Despite the extensive body of knowledge that exists in the field, there appears to be no universally accepted definition. The many definitions that exist in KM literature, serves as a means to illustrate these various perspectives. Scarborough (1996) commented on this diversity by stating that "the sprawling and eclectic literature and the ambiguity and definitional problems ... allow different groups to project their own interests and concerns onto it". In order to make sense of the field, the following section aims to provide an overview of the key definitions used in the field with reference to their respective perspectives.

The first set of definitions look at KM from a social and human view point (Table 2.10). These definitions of see KM as a means of managing the human factors associated with knowledge. This is in keeping with the idea that knowledge is found by and created in people.

Social and Human Perspectives of KM		
Brooking, 1997	"KM is the activity which is concerned with strategy and tactics to	
	manage human centred assets."	
Stuart, 1996	"Efforts intended to retain, analyze and organize employee expertise,	
	making it easily available anywhere, anytime ideally and ultimately to	
	improve the bottom line."	

Table 2.6 Social and Human Perspectives of KM

In stark contrast, more techno-centric definitions attempt to omit the 'softer' organisational aspects in favour of "*hard*" ones. They see KM as a systematic approach to effective use of IT tools and technologies in order create value in the organisation. These perspectives, illustrated in Table 2.11, seem to be criticised by many authors who argue that technology is merely an enabler of KM process (Peters, 1992).

Techno-Centric Perspectives of KM		
Frappaulo &	"KM is a toolset for the automation of deductive or inherent	
Toms, 1997	relationships between information objects, users and processes."	
Allee, 1997	"Technology and interior structure of a firm which can help people	
	rethink the knowledge in the organization and help people communicate"	

Table 2.7 Techno-Centric Perspectives of KM

A broader standpoint is the view that KM is centred on the management of Intellectual Capital and can be viewed as a means of wealth creation within an organisation. The definitions, in Table 2.12, see KM as a means of managing knowledge resources for the benefit of the organisation from the human and technology perspective.

Intellectual Capital Perspectives of KM		
Sveiby, 1997	"The art of creating value from an organisation's intangible assets"	
Bukowitz &	"Knowledge Management is the process by which the organisation	
Williams, 1999	generates wealth from its knowledge or intellectual capital."	
Rosemann, 2000	"Knowledge Management seeks to deal with the problem of leveraging	
	knowledge resources in an organisation."	

Table 2.8 Intellectual Capital Perspectives of KM

Perhaps the most common view, when defining KM, is that it is seen as the sum of its knowledge processes. These definitions highlight the activities that allow knowledge to be captured and incorporated it into an organisations business practices (Table 2.13). The body of knowledge, which supports these perspectives, sees KM as a means of creating value when knowledge is shared and reused.

The final perspective, in the definition of KM, is based on a more integrated and holistic view. These definitions, and the bodies of knowledge they represent, place KM in a broader business context, focusing on the role that KM plays within an organisation and illustrates how an organisations shape and operations can be affected

by KM (Table 2.14). They also make reference to external influences on the organisation. In Taylor *et al.* (1997) definition, they speak of "powerful external forces" which create pressure in organisations, in turn leading to the need for effective KM.

Knowledge Processes Perspectives of KM		
Alavi and	"Distinct but interdependent processes of knowledge creation,	
Leidner, 2001	knowledge storage and retrieval, knowledge transfer and knowledge	
	application."	
Wiig, 1997	"KM focuses on facilitating and managing knowledge related activities	
	such as creation, capture, transformation and use."	
Watanabe &	"Knowledge management can be defined as the process for acquiring,	
Senoo 2008	storing, diffusing and implementing both tacit and explicit knowledge	
	inside and outside the organisations boundaries with the purpose of	
	achieving corporate objectives in the most efficient manner"	

Table 2.9 Knowledge Processes Perspectives of KM

Holistic Perspectiv	ves of KM
Taylor et al.,	"Powerful environmental forces are reshaping the world of the manager
1997	of the 21st century. These forces call for a fundamental shift in
	organization process and human resource strategy. This is Knowledge
	Management."
Quintas et. al,	"Knowledge management is the process of critically managing
1997	knowledge to meet existing needs, to identify and exploit existing and
	acquired knowledge assets and to develop new opportunities."
Holsapple &	"Knowledge Management is an entity's systematic and deliberate efforts
Joshi,	to expand, cultivate, and apply available knowledge in ways that add
2004	value to the entity, in the sense of positive results in accomplishing its
	objectives or fulfilling its purpose"

Table 2.10 Holistic Perspectives of KM

As means to integrate these definitions, we will look at the definitions in the context of the three major components that are associated with KM, People, Processes and Technology (Figure 2.8).



Figure 2.8 People, Process and Technology

Central to all organisations are its people. People are responsible for creating, sharing, and using knowledge. From the social perspectives in Table 2.14, KM is seen as a means to managing the knowledge of people. Stuart's definition of KM makes explicit reference to managing the collective (groups and the organisation itself). Organisations must facilitate the cultivation of expertise by providing an appropriate organisational culture that nurtures and stimulates knowledge sharing. The intellectual capital perspective would also fall into this category (Table 2.12). People are ultimately responsible for the activities of an organisation. Therefore they are responsible for the creation of an organisations wealth.

The next component of the organisation is its processes. The definitions in the Knowledge Processes (Table 2.13) highlight this view. KM is used to manage the processes that are required to acquire, create, organise, share and transfer knowledge.

The final component of the triumvirate is technology. Technology is a mechanism used to store and provide access to data, information, and knowledge created by people within the organisation. The techno-centric perspectives of KM in Table 2.8, illustrate the importance of KM in providing a set of tools which allow individuals, groups, organisations and extra-organisational entities to collaborate and create new knowledge.

As we can see in the Figure 2.8, these components are very much interrelated and it's this synergy, illustrated in the holistic perspectives, that defines KM in reference to the bigger picture. To put into perspective the goal of the thesis, we can use the dimensions of the people, processes, and technology triumvirate as a metaphor i.e. to encapsulate the knowledge from an expert (people) pertaining to the techniques (processes) in the field in order to use technology in the creation of a knowledge artefact.

2.4.2 Why Knowledge Management?

In today's business climate, organisations face a growing list of challenges (Knowledge Management Library, 2010). In terms of production, organisations are required to develop new products and innovations at a faster rate in order to remain competitive. There is a growing emphasis on creating customer value and improving customer service. Organisations are required to adapt in the face of new and changing business regulations and best practices. We have seen widespread downsizing resulting in the incalculable loss of knowledge which is often irreplaceable. Organisations are required to operate with an ever-decreasing pool of assets (e.g. people, inventory, and services) which has negatively impacted on its capacity to remain competitive. This has put pressure on employees as they are now required to rapidly acquire new knowledge. This volatility demands organisations to adopt new approaches in order to remain competitive.

Knowledge management is a direct response to these challenges. Malhotra (1998) spoke of this in which KM provides a means of responding to "the critical issues of organisational adaptation, survival and competence in face of increasingly discontinuous environmental change". The importance of KM is confirmed by various research studies. A survey of CEO's attending the World Economic Forum 1999 found that 97% of senior executives saw knowledge management as a critical issue within their organisations (Abramson, 1999). Whilst a survey of 423 organisations in the UK, mainland Europe and the US, found that 81% of respondents had either adopted or were considering adopting knowledge management within their organisations. 79% of the organisations surveyed also believed that knowledge management can play an

"extremely significant" or "significant" role in improving competitive advantage. (KPMG, 2000)

There are a variety of benefits that have been attributed to the successful adoption of KM within an organisation. KM promotes the creation of communities of practice that provides a forum allowing the free flow of ideas to create "*new knowledge*". Sternberg (1999) links the creation of "new knowledge" to innovation, thus providing a mechanism whereby organisational value is created through new products or services. KM can also enhance the value of existing products, through the elimination of redundant processes and promoting reuse, leading to greater productivity; making it easier for organisations to get products and services out in the market faster (Parker *et al.*, 2005). KM can also improve employee retention through recognition of the employees' value and providing a reward scheme in appreciation of their efforts. Peters (1992) speaks of the "*expert status*" of knowledge workers with "*managers often taking more than one role*". Workers benefit in terms of increased autonomy and the intrinsic benefit of increased learning. As we saw in Choo's Organisational Knowing Cycle, in section 2.3.2, the increased knowledge of workers leads to more informed decisions by reducing uncertainty (Choo, 1998).

2.4.3 Knowledge Management Initiatives

There is much confusion in what constitutes a knowledge initiative and how they differ from initiatives in information science. In section 2.1.1 we defined information as the as a flow of messages whilst knowledge was the combination of information and context in such a way that makes it actionable. In reality, most projects are often mixture a mix of knowledge and information management. In table 2.15, *DeLong et al.* (1997) identified several characteristics that help differentiate them from traditional information management projects. As we see the shift from Information Management to Knowledge Management, the goals establish the need for a new emphasis on knowledge.

Information Management Project	Knowledge Management Project
Goals emphasise delivery and accessibility	Goals emphasise value-added for users
of information	
Support existing operations	Support operational improvement and
	innovation
Delivers available content with little value	Adds value to content by filtering,
added	synthesising, interpreting, pruning content
Emphasis on one-way transfer of information	Usually requires ongoing user contributions
	and feedback
Heavy technology focus	Balanced focus on technology and culture
	issues in creating impacts
Assumes information capture can be	Variance in inputs to system precludes
automated	automating capture process

Table 2.11 Difference Knowledge Management and Information Management Projects

To emphasise this transition, *DeLong et al.* (1997) observed seven types of initiatives in these organisations based on a survey more than twenty knowledge management initiatives in ten organisations (illustrated in table 2.16). These categorisations are not mutually exclusive. An example of this would be the creation of a demonstrational video based on the use of an SME. Such an initiative would incorporate elements such as the identification of sources and networks of expertise, the capturing and sharing of lessons learned from practice, the structuring and mapping knowledge needed to enhance performance as well as the embedding of knowledge in the product (i.e. the instructional video).

Туре	Definition	Examples
Capturing and reusing	Finding knowledge embedded in	Skandia imbedded its experience setting up
structured knowledge	organisational components (e.g. product	operating units into administrative modules
	design, project proposals, implementation	that reduce the start up time from seven years
	procedures, etc.) that can be reused to	to seven months which enabled faster
	reduce time and resources needed to	expansion of international operations.
	produce a new output.	
Capturing and sharing lessons	Capturing and distributing experiential	US Army's Centre developed an elaborate
learned from practice	knowledge for employees to use in a new	lessons learnt infrastructure developed for
	context.	capturing and sharing new knowledge from
		field operations
Identifying sources and	Exposing organisational expertise and	Teltech created a network of external experts
networks of expertise	making it accessible to employees thus	for clients who seek technical expertise in a
	creating connections between experts and	specified domain.
	those who need the knowledge.	
Structuring and mapping	Making explicit specific knowledge	Hoffman-LaRoche created a "knowledge
knowledge needed to enhance	needed at particular stages of an initiative	map" of the new drug application process.
performance.	(e.g. product development, process	The initiative detailed the knowledge required
	redesign, etc.)	by the regulators in order to approve a new
		drug.
Measuring and managing the	Managing an organisations knowledge	Dow Chemical, created an infrastructure to
economic value of knowledge.	assets (e.g. patents, copyrights, and	organise and classify its patents to determine
	customer data, etc.) more judiciously (i.e.	which ones represent strategic advantage,
	revenues and costs associated with an	which present revenue opportunities from
	asset).	licensing, and which patents should be
		abandoned.
Synthesising and sharing	The creation of tools which synthesise	Hewlett-Packard developed a system to
knowledge from external	knowledge from multiple sources of	provide marketing intelligence for both
sources.	knowledge and distribute it individuals in	domestic and international business units.
	the organisation who require it.	These systems require editors, reporters, and
		analysts to synthesize and provide context to
		the volumes of market information.
Embed Knowledge in Products	Projects that enhance or create new	AutoDesk embedded the engineering designs
and Processes.	knowledge intensive products, services,	created by customers using its product
	and processes.	AutoCAD enabling re-selling of designs to
		other firms working in similar areas.

Table 2.12 Types of Knowledge Management Initiatives

(DeLong et al., 1997)

2.4.4 Models of Knowledge Management

Many models that exist in knowledge management focus on the concepts proposed by Nonaka in the SECI model. It can be argued that the SECI model in itself is a model for knowledge management. However in order to provide an in-depth perspective in the field, the following sections looks at three alternative models. We start with the Intellectual Capital Perspective, through the Skandia Intellectual Capital Model in section 2.4.4.1. As we stated in section 2.4.1, these models view KM as a means of wealth creation in the context of an organisation. In section 2.4.4.2, we look at personal knowledge management as a means challenging the traditional view that knowledge management is a top down initiative. The Demarest model (section 2.4.4.3) pertains to a holistic conceptual view of knowledge management focusing on the movement of knowledge from its inception through to its eventual use.

2.4.4.1 Skandia Intellectual Capital Model

Led by Leif Edvinsson, the world's first Chief Knowledge Officer, Skandia developed an intellectual capital model used as a means to measure and manage its intellectual capital (Edvinsson, 1997). In Edvinsson's model (figure 2.9), he proposed that the market value of an organisation is not just made up of the wealth contained in its financial capital but also in the intellectual capital (IC) that exists within an organisation. In defining IC, Edvinsson stated that IC is comprised of human capital and structural capital. Human capital is defined as the knowledge, skills and expertise of organisations employees. In this, Edvinsson recognised the value of an organisation's employees in their ability to add value to the various products and services, at the heart of an organisation's activities, through the application of their skills. To ensure that the intellectual capital is managed correctly, human capital management is employed. Organisations are responsible for managing and maintaining the knowledge base of individual workers whilst encouraging and motivating them to turn their tacit knowledge into explicit knowledge.

Moving down the model, we see that structural capital is the aggregation of customer capital and organisational capital. Customer capital refers to an organisation's relationship with external entities. This relationship is either strengthened or weakened by factors such as customer loyalty, the extra-organisational reputation of the organisation, as well as its relationships with other stakeholders (e.g. suppliers, partners, *etc.*). Organisational capital, on the other hand, represents an organisation's

capabilities to meet its external and internal challenges. Organisational capital consists of innovation capital (e.g. intellectual property rights, the provision of an organisation knowledge culture, *etc.*) and process capital (i.e. the provision of a support technical infrastructure).



Figure 2.6 Skandia Knowledge Management Approach

(Edvinsson, 1997)

Edvinsson concluded that IC should not only be concerned with traditional intangible assets (i.e. brand recognition, trademarks and goodwill), but also other intangibles found in knowledge, technological value and customer relationships. In addition to financial capital, these assets represent the resources required for an organisation to obtain a competitive advantage in a competitive market place.

2.4.4.2 Personal Knowledge Management

The traditional organisational perspective is that KM initiatives are driven top-down. Organisations have been responsible for creating a supporting infrastructure to facilitate KM activities. This has been achieved by provision of company wide content management systems as well as implementing a change management program in which workers are encouraged to externalise and share knowledge between co-workers. Despite the promises of KM, some studies report that as much as 84% of KM projects fail to achieve their initial goals (BenMoussa, 2009). One way in which this can be addressed is the adoption of a more pragmatic approach to KM, Personal Knowledge Management (PKM).

PKM is a relatively new field in KM that can be traced back to a working paper in 1999 from Frand and Hixon (Frand & Hixon, 1999). It centres on the study of the processes that a knowledge worker carries out in order to gather, classify, store, search, and retrieve knowledge to support their day-to-day working routine (Grundspenkis, 2007). The PKM perspective is a bottom-up initiative, whereby responsibility for knowledge work is the duty of the individual. The integration of technologies, enabled through technologies such as Web 2.0, allows individuals to manage their own personal body of knowledge. Such initiatives are seen by organisations as low cost, in that they are supported by experts without the reliance of support teams (e.g. human resource management, knowledge engineers, *etc.*). For these types of initiatives to be successful they must be highly visible, rapidly implemented and produce tangible results.

An example of such activities is personal knowledge audits whereby individuals document their own personal knowledge and identify gaps which must be addressed. Other initiatives such as the creation of personal knowledge yellow pages, in which an individual explicitly identifies the key individuals, departments, and projects pertaining to the work they are involved in. Once these knowledge artefacts have been

created, they can be easily distributed to their working groups for peer analysis, which in-turn can be further added to and eventually distributed to organisational and extraorganisational level.

In using PKM, organisations gain from the company wide exposure of the knowledge assets which each individual employee possesses. A successful small scale PKM initiative can breed confidence into an organisation and thus supporting the necessary cultural change, required as a pre-cursor to the adoption of organisational wide Knowledge Management initiatives.

2.4.4.3Demarest's Model of Organisational Knowledge

Another perspective on knowledge management is Demarest's model (1997) in which he looks at the construction of knowledge within an organisational domain. The model illustrates how constructed knowledge is embodied and distributed throughout an organisation with the goal of using knowledge to gain economical benefit.



Figure 2.7 Demarest's Model of Knowledge Management

(Demarest, 1997)

To demonstrate this, Demarest uses the model in figure 2.10 to represent an organisation's knowledge economy. In the context of this model, four processes are identified; *Construction, Embodiment, Dissemination* and *Use*.

Demarest defines *construction* as the process of discovering or structuring knowledge. This is achieved using complex processes such as knowledge creation, translation and reinterpretation of existing knowledge. In terms of an organisation, it can be found in everyday processes e.g. how to sell specific products to a particular market, how to diagnose a particular kind of customer problem, *etc.* The next process is *embodiment*. In the context of the model, embodiment is referred to as the process of selecting a container for which knowledge, once it has been constructed, resides. Typically this process involves the conversion of knowledge that is held in the minds of individuals and shared in secrecy within groups, into containers such as organisational processes and practices, products and cultures. *Dissemination* is the concerned with the human processes and technical infrastructure required to distribute embodied knowledge throughout an organisation and it's supporting external entities (e.g. suppliers, customers, partners, *etc.*). And finally, *use*, which is concerned with the application of knowledge that has been disseminated, embodied to specific problems and classes of problems, with the goal of commercial value.

The movement of Knowledge is illustrated in Figure 2.10. The solid arrows show the primary flow direction whilst the plain arrows show the recursive flows. The recursive flow from Construction-to-Use represents how knowledge is put into practice, whilst knowledge is being constructed, as a means of testing-for-use-value required during the knowledge construction process. The recursive flow from Construction-to-Dissemination demonstrates the creation of value whereby constructed knowledge is tested, validated and critiqued by peers in the form of review cycles. Once these two recursive cycles have been successfully executed the Construction-through-Embodiment-through-Dissemination-through-Use flow details the formal process required to embed knowledge into organisational products.

2.4.5 The Knowledge Management Processes

In our discussion of the knowledge creation models in section 2.3.4, reference was made to various knowledge creation processes that exist. These processes are at the heart of Knowledge Management. They are required in order to facilitate the flow of knowledge from its inception through to its diffusion throughout an organisation. From the models examined in the course of the KM literature review, there appears to some correlation between the various sources. As a basis for comparison, we shall use the definitions of Becerra-Fernandez *et al.* (2004) to illustrate where these models insect.

2.4.5.1 Knowledge Discovery

The first KM process is *knowledge discovery*. In this they defined knowledge discovery as "*the development of new tacit or explicit knowledge from data and information or the synthesis of prior knowledge*". This definition maps well into Choo's sense-making process (section 2.3.2) whereby external signals from the environment are used to create shared meanings essential in his knowledge creating process. The inclusion of prior knowledge in the definition also allows this definition to be mapped neatly into the socialisation phase of the SECI model (2.3.3). Whilst there are certain similarities with Demarest's definition of construction in isolation (section 2.4.4.3), when this phase is used as part of the flows described in the construction of knowledge (i.e. Construction-to-Use, and Construction-to-Dissemination) it makes use of processes involved in the Knowledge Sharing and Knowledge Application phases.

2.4.5.2Knowledge Capture

The next phase used Becerra-Fernandez is *knowledge capture* and is defined as "*the process of retrieving either explicit or tacit knowledge that resides within people, artefacts or organisational entities*". In terms of the SECI model (section 2.3.3), the process of retrieving knowledge from explicit knowledge from organisational entities, is more akin to combination whilst the process of retrieving tacit knowledge from people is characteristic of Nonaka's externalisation phase. In terms of Choo's model (section 2.3.2), this work primary take place in the knowledge creation phase with input from the sense making and decision making processes. In terms of Demarest's model (section 2.4.4.3), the knowledge creation phase maps into the construction and embodiment phase.

2.4.5.3 Knowledge Sharing

Knowledge sharing is defined as "*the process through which explicit or tacit knowledge is communicated to other individuals*". From our literature review, we see that Demarest's notion of dissemination (section 2.4.4.3). In the SECI model (section 2.3.3), Nonaka separates the communication process of knowledge into internalisation, whereby explicit knowledge is communicated, and socialisation, which is primarily concerned with the communication of tacit knowledge. Choo's notion of sense-making (in terms of the exchange of tacit knowledge) and knowledge creating (in terms of communication through explicit artefacts) seems to encapsulate the knowledge sharing process (in section 2.3.2). The apprenticeship model is concerned fully encapsulates the formal process of tacit knowledge creation in the observation, coaching and practice phases (section 2.3.3).

2.4.5.4Knowledge Application

Our final definition is the *knowledge application* process in which Becerra-Fernandez succinctly defines as the process whereby "*knowledge is used to guide decisions and actions*". This definition maps perfectly into Choo's decision making process (in section 2.3.2) as well as Demarest's use phase (in section 2.4.4.3). In terms of the SECI model (in section 2.3.3), the application of knowledge appears to be implicit in the externalisation phase (in the creation of knowledge artefacts) and the combination (the creation of contextual knowledge repositories).

2.5 Conclusion

In this chapter, we provided a clear definition of Knowledge, differentiating it from data and information. We looked at the different categorisations of knowledge and provided a contextual view of knowledge in organisations and the various entities where knowledge resides. This chapter discussed the various models of organisational knowledge creation. The field of Knowledge Management was discussed. We concluded the section by looked at its purpose and provided a high level view of the knowledge processes that exist.

In order to put the thesis in context with the themes discussed in this chapter. The thesis is concerned with the elicitation of knowledge (section 2.2.1). Focusing on deep (section 2.2.2.2), tacit (section 2.2.2.1), procedural (section 2.2.2.3) knowledge required in the performance of MMA techniques. For this purpose, we will be using an expert (section 2.2.3.1) from the grappling group (section 2.2.3.2) at the Team Ryano organisation (section 2.2.3.3), whose knowledge in the field, has been constructed from years of experience (section 2.3). In performing, this activity we shall be using systematic techniques from the field of knowledge management (section 2.4). The initiative (section 2.4.3) will use techniques specific to the knowledge capture (section 2.4.5.2) in order to produce a valuable artefact (section 2.4.4.1) which can be used within the organisation or distributed to an extraorganisational level (section 2.2.3.4) to add to the existing body of knowledge in the field of mixed martial arts.
3 KNOWLEDGE ACQUISITION AND ELICITATION

"There are known knowns. These are things we know that we know. There are known unknowns. That is to say, there are things that we know that we don't know. But there are also unknowns unknowns. These are things we don't know we don't know."

Donald Rumsfeld

3.1 Introduction

In this chapter, we will look at the field of Knowledge Acquisition, focusing on the various subsets of the subject as well as the issues which affect each type in the acquisition of knowledge. From this our focus will shift to the subject primarily concerned with the elicitation of knowledge from a human expert, known as knowledge elicitation (KE). In this section, we will provide an overview of the area, looking at the various influences which have directed research in the area. The issues and requirements for KE will be addressed. We will look at the various classifications of KE and identify the use of KE in terms of the Knowledge Capture process (identified in section 2.4.5.2).

3.2 Knowledge Acquisition

A subset of the Knowledge Capture process is the Knowledge Acquisition (KA). KA is defined as the process of acquiring knowledge from a problem domain. The techniques used in KA allow knowledge to be collected from different knowledge sources which can be validated and maintained (Cooke, 2003). The processes are centred on the elicitation, collection, analysis, modelling and validation of knowledge for knowledge engineering and knowledge management projects (Gronau *et al.*, 2005). In this section, we will first look at the issues which affect the field known collectively as the *"knowledge acquisition bottleneck"* (section 3.2.1). This will be followed in section

3.2.2 by an overview of the KA techniques and see where these techniques aim to resolve the problems associated with the bottleneck.

3.2.1 Knowledge Acquisition Bottleneck

The problems that are associated with the acquisition of knowledge are known as the *Knowledge Acquisition Bottleneck*. Wagner (2003) classifies these issues into three broad categories, *narrow bandwidth, acquisition latency and knowledge inaccuracies*.

The first category, *Narrow Bandwidth*, is concerned with the relatively limited number of channels that exist from which knowledge can be acquired. As seen in section 2.2, knowledge exists both tacitly and explicitly in individuals, groups, organisational entities as well as extra-organisational entities. However when we are trying to capture specific knowledge, it often resides in only a few of these entities. Once these sources have been identified, another factor that influences bandwidth is the availability of knowledge sources. In dealing with human sources, its availability is particularly problematic. Organisations are often reluctant to move Subject Matter Expert (SME)'s from their day-to-day functions in order to participate in knowledge initiatives, due to the cost of the resource as well as the impact, their absence, has on the primary functions.

The next type of problem associated within the Knowledge Acquisition Bottleneck is *Acquisition Latency*. This pertains to the time taken from the creation of knowledge to when knowledge is available and ready to be shared. The acquisition of knowledge from a knowledge sources can be problematic. For the most part, knowledge is located in the minds of individuals. In terms of deep knowledge, typical of the knowledge found in experts, this can be vast. Depending on the ability of an SME to articulate their knowledge, this can be time consuming and an arduous process. The mind can create representations of this knowledge that makes it difficult to describe, so much so, that often experts do not fully understand all they know.

The final component is *Knowledge Inaccuracy*. This refers to the mistakes made in extraction of knowledge from knowledge sources both in the initial knowledge capture

phase as well as the maintenance phase, required in the growth of the knowledge bases. Care must be taken in these stages; inaccurate knowledge put into the knowledge initiative can result in a layer unnecessary complexity, built on false premises, making it fundamentally inaccurate and difficult to maintain (Land, 2002).

3.2.2 Knowledge Acquisition Techniques

Given these challenges, Knowledge Acquisition requires a set of tools that address each of the bottlenecks. Knowledge Acquisition Techniques can be classified into three types according to the way they can deal with knowledge collected (Turban and Aronson, 1998). These types are Automated Knowledge Acquisition Techniques, Semi-Automatic Knowledge Acquisition Techniques and Manual Knowledge Acquisition Techniques.

3.2.2.1 Automated Knowledge Acquisition Techniques

Automated Knowledge Acquisition techniques are defined as a set of tools and techniques designed to overcome the limitations of acquiring knowledge from human sources (Wagner, 2000). Typically these tools lie in the realm of machine learning (e.g. data mining, neural networks, fuzzy logic, genetic algorithms, *etc.*). Figure 3.1 illustrates the automated knowledge acquisition process.



Figure 3.1 Automated Knowledge Acquisition

These tools aim to address problem of latency, by reducing the time taken and expense incurred in the knowledge acquisition phase. Techniques in this area use non-human sources (such as organisational corpora, databases, *etc.*) to acquire knowledge thus

removing the time constraints placed on key human sources. Automated KA techniques can resolve issues associated with knowledge inaccuracies. The systematic approach can expose naturally existing correlations in datasets that are not easily obtained from other types of KA tools; thus making its use, in complex domains, significant. Application to group, organisational, and extra-organisational knowledge artefacts allows knowledge to be collated from different sources; thus addressing the narrow bandwidth issues associated with the use of a single knowledge source by creating a synthesis of expertise that is less prone to error.

However, the key problem with these techniques is the omission of human expertise. A survey conducted in 2000 estimated that over 90 percent of organisational knowledge is not codified but resides tacitly an organisations entities (Bonner, 2000). By eliminating these sources from the knowledge acquisition process, they are decreasing the bandwidth significantly, impacting on the accuracy of KM initiatives. Another problem associated with the accuracy problem is the inability of these techniques to evaluate the relevance of knowledge and the knowledge sources. A systematic approach treats all sources with the same value. Another concern that can be attributed to the use of automated KA tools is the need for accurate datasets. The datasets, used in the development of this knowledge, must be fully representative of the domain. Missing or limited datasets can seriously impact the KA process. A further limitation of automated KA techniques, such as neural networks, is the lack of an adequate explanation system. The difficultly associated with human comprehension of rules generated, discourages the wide-spread utilisation of automated KA techniques in mission critical systems where answers are required when things go wrong.

3.2.2.2 Semi-Automated Knowledge Acquisition Techniques

The next sets of tools are concerned with the use of semi-automated KA techniques. These techniques are intended to support KA process in one of two ways. The first is to provide SMEs with tools that facilitate the creation of knowledge bases with minimal assistance from knowledge engineers, thus reducing the effects of latency. An example is found in Marshall and Bandar's (1999) work whereby a tool was created in order to assist the acquisition of medical terms from medical corpora, the results of

which were presented to lexicographer for dissemination. These types of tools improve the quality of acquired knowledge, through explicit sources, by using an expert in the field, to validate results.

Another group, that exists in this subset, are the techniques which assist the knowledge engineer, to execute the KA activities in a more efficient and effective manner by minimising time spent with the SME; thus addressing the issues of latency. Examples of these types of tools, includes techniques such as repository grid analysis whereby key attributes are identified and are weighted in the decision making process. As we can see in Figure 3.2, these techniques benefit from the use of SME's in the knowledge acquisition process therefore increasing the bandwidth of knowledge sources. However Turban and Aronson (1998) sees the adoption of these tools as best suited to well-structured problems such as diagnosis and classification but warns that such techniques do not provide a deep understanding of the decision making process.



Figure 3.2 Semi Automated Knowledge Acquisition

3.2.2.3 Manual Knowledge Acquisition Techniques

In order to access the deep knowledge of organisational knowledge sources, manual methods of KA are required. Knowledge engineers use these techniques in order

capture knowledge from both knowledge artefacts and human sources in order to populate knowledge bases (Figure 3.3).

In creating new knowledge from knowledge artefacts, one way in which this can be achieved is a through a systematic review. These reviews focus on summarising a body of literature by identifying, appraising, selecting and synthesising research evidence. From this, conclusions can be reached that are relevant to the questions being asked. In academia, an example of this would be a literature review, in which, a body of work, is reviewed; citing the current knowledge in the field referring to the topic being considered. In fields such as evidence-based medicine, these types of reviews are essential (CEBM, 2009). In terms of the KA bottleneck (section 3.3.2.1), we see that dealing with only explicit artefacts, greatly reduces the bandwidth of sources in which these techniques operate. The elimination of human resources is problematic. To address this manual methods that employ the use of human sources are required. These methods used a variety of techniques to elicit knowledge from a human source.

Using manual methods, we employ techniques that provide a richness of detail (with access all the various types of knowledge detailed in section 2.2.2) which cannot be achieved using automated or semi-automated methods. However manual methods are slow, expensive and are often subject to bias especially when dealing with a single expert. Multiple sources can be employed to increase the accuracy of the knowledge acquired by eliminating bias. However a significant price is paid in terms of latency, which is also impacted by the associated with the depth of analysis required to externalise new knowledge.

In terms of our research, we will be extracting knowledge with a SME in the field of Mixed Martial Arts. The acquisition of knowledge from human sources is a subset of KA known as Knowledge Elicitation. In the next section, we will focus on the body of research that exists within the field.



Figure 3.3 Manual Knowledge Acquisition

3.3 Knowledge Elicitation

As we have seen in the Knowledge Acquisition process, KA can occur with respect to the use of Subject Matter Experts as well as individual, group, organisational and extra-organisational knowledge artefacts. At the end of section 2.2, we looked at manual methods of KA and made reference to the subset of KA, the field of study revolving around the acquisition of knowledge from human sources is known as Knowledge Elicitation (KE).

In this section we aim to add to its definition by providing an overview of the subject with reference to the current understanding in the field. In section 3.3.1 we will provide an overview of the subject with reference to its historical roots as a means of defining the subject. Section 3.3.2 will look at the issues that are inherited from KA as well as the issues that are specific to KE. In section 3.3.3, we will look at the requirements for KE in order to mitigate the issues addressed in section 3.3.2. Once addressed, section 3.3.4 will focus on the tools used in order to perform KE, focusing on the various categorisations that exist in the field. In section 3.3.5, we will look at the models that exist in order to implement KE.

3.3.1 Overview

Knowledge Elicitation is a multi-disciplinary field that can be traced back to the enlightenment period in which the eighteenth century. This period is characterised by its great works in which reason was advocated as the primary source and legitimacy for authority. Early works included the *encylopedie* by Diderot (1751-1772), in which he explained the knowledge and procedures involved in trades craft.

The field of knowledge elicitation, as we know it today, finds its roots in the era of Expert System development (circa 1971). The earliest example lay in the creation of system to interpret mass spectrograms by a team of scientists led by Edward Feigenbaum (1971). The system involved the elicitation of knowledge from skilled chemical experts which was then transformed into domain rules which were then integrated into an inference engine. This research led the way in the field of Expert Systems. During this period, the problems associated with the elicitation of domain knowledge, were identified and labelled as the *knowledge acquisition bottleneck* (indentified in section 3.2.1). From this spawned the development of semi automated knowledge acquisition tools, whereby domain expert directly embedded in rules in the inference systems themselves. Problems occur when experts do not fully understand their own reasoning process (Hoffman & Deffenbacher, 1992). Characteristically, these systems were often limited in their ability to deal with atypical situations as well as providing a sufficient explanation system required to clarify the decisions generated.

At the same time, developments in Cognitive Psychology and the Learning Sciences also impacted KE. Studies in this field focused on the identification of the basis of expertise and knowledge organisation at different stages during the acquisition of expertise (Lesgold, 1984; Means & Gott, 1988). The projects in the field of Instructional Design, benefitted greatly from this research, by proposing new methods in which learning activities were designed in relation to the difficulties and direction of transfer (Gagne & Smith, 1994). Interest in Instructional Design led research into the examination of the psychology of expertise (Glaser, 1987). From this the term "*Cognitive Task Analysis*" was created. The research involved the identification of knowledge and the strategies that make up expertise. In this, research shifted from the

use of using subjects in academia to the use of skilled workers in the "*real world*" in order to add validity to the research (Chi at al, 1988). With this shift saw the move from cataloguing bias' and limitations of human reasoning, in artificial and simplistic domains, to the exploration of human capabilities in regard to the decision making processes, complex problem solving and the formation of mental models (Gentner & Stevens,1983; Scribner, 1984). It was seen that experts do not simply follow codified work rules and processes but in fact they develop their own informally heuristic strategies which are robust, effective and cognitively efficient (Lave, 1988).

Today the delineation between academia and industry has almost completely been dissolved. Organisations, such as Skandia, advocate the use of KE as apart of its KM model (detailed in section 2.4.4.1). Consultancy companies, such as. Epistemics, offering KE services to public and private sector organisations in fields as varied as Finance (Prudential), British Steel, Health and Safety Executives and Cancer Research UK to assist in the KE from experts in the field. As we can see from table 3.1, KE plays an enormous role in various activities such as Knowledge Management, Organisational Analysis, Task Analysis, User Analysis and Requirements Elicitation.

Field	Tasks
Knowledge Management	Technological Innovation
	Ontology Construction
	Document Mark-Up
Organisational Analysis	Process Approaches
Task Analysis	Job Design
User Analysis	Generation of Cognitive Specifications for Tasks
	The Mitigation of Human Error in Domains of Risk or Time
	Pressure
	The Enhancement of Proficiency through Training and Skill
	Remediation
Requirements Elicitation	Systems or Design Analysis
	Conceptual Database Design
	Software Requirements Definition

Table 3.1 Role of Knowledge Elicitation

A hangover from the behaviourist movement is the idea that routines and task, located tacitly in the minds of an expert, are inexpressible via introspection. This notion has never been formally demonstrated (Hoffman & Lintern, 2006). In principle, all tacit knowledge can be elicited. It is the collaborative process (i.e. the interactions between a knowledge engineer and an expert) and the quality of the techniques used that provides a mechanism for its discovery. Once the formally interactions between the Knowledge Engineer and the SME have been conducted, the knowledge gained can be used in the creation of models pertaining to a practitioner's knowledge and reasoning specific to work tasks in a domain of knowledge. The integration of individual models, in the same domain, can help synergise ideas and present a collective model of the work domain as a whole. From this, we can identify various components of knowledge (e.g. domain concepts, best practices, *etc.*), and knowledge used in the creation of knowledge based products. In tackling KE, the underlying question is succinct and simple; "*how can we effectively elicit knowledge from an expert*?" (Cooke, 1994).

3.3.2 Issues in Knowledge Elicitation

In adopting KE as the basis for the KA process, not only are the difficulties associated with KA (knowledge acquisition bottleneck) inherited, but there are also issues specific to KE which need to be addressed. The development of a knowledge base is problematic and requires considerable time and effort of both the knowledge engineer and domain expert. In order to identify the issues, we need to examine them from the conception of the process, through to the selection of KE, and also the concerns encountered in the elicitation process with reference to issues which arise from the perspectives of SMEs and Knowledge Engineers.

3.3.2.1 Issues in Initialising the Knowledge Elicitation Process

In initialising a knowledge elicitation process, we are immediately met with issues that impact the bandwidth. The selection and availability of SMEs is critical to the success of KE initiatives. Whilst the use of a single SME might be sufficient in some situations, in others it is not. Martinez-Bejar *et al.* (1996) use an example from the field of environmental planning task to illustrate this complexity, whereby expertise, in areas such as botanical, zoology, ecology, economy, and forestry engineering, are required. In this, they assert that the availability of a single domain expert with knowledge in is highly unlikely. Impacting the bandwidth further is globalisation as expertise is often distributed globally. This adds to the expense of the KE process whereby experts / knowledge engineers; required participants to travel long distances in order to contribute to KM initiatives.

In Okafor and Osuagwu's discussion of the underlying issues in KE, they identified several issues which are concerned with the difficulties in encouraging experts to participate KE process (Okafor and Osuagwu, 2006). The first is that expert knowledge is in high demand; busy schedules leave little or no time for participation in elicitation sessions. They also made reference to the intrinsic fears associated with the loss of unique knowledge, previously used by experts to guarantee relevance, status or job security within an organisation. At the other end of the spectrum, an expert might be reluctant to participate in KE if they feel that the elicited knowledge will not be put to use. Another problem, that Neve (2003) alludes to, is when individuals are unaware of the tacit knowledge they possess, this can result in them feeling that their participation in the KE process is pointless.

Another factor that affects the narrow bandwidth is an organisations ability to find appropriate knowledge engineers to perform the KE task. As some domains are highly complex, finding people with an appropriate skill set can be extremely problematic.

These resources are costly to an organisation. In this sense, the KE process is an important cost-determining factor in the whole KA process (Martinez-Bejar *et al.* 1996). For this reason, organisations look to eliminate the need for knowledge engineers, either through the use of automated knowledge acquisition techniques (detailed in section 3.2.2.1) or through the adoption of bottom up approaches seen in the personal knowledge management model (seen in section 2.4.4.2). However, in many situations, the interaction between a knowledge engineer and domain expert remains indispensable.

There are also issues of acquisition latency that must be addressed at the start of the KE process. Some domains are highly complex; the effort to elicit knowledge is high in terms of time and expertise required to perform the KE process (Martinez-Bejar *et al.* 1996). The use of multiple experts, from very different fields, also has implications in terms of the language each used to describe concepts in their own particular domain. Whilst concepts might be semantically similar, the terms used could differ. This could impact attempts to synergise the collective knowledge.

In dealing with knowledge inaccuracies, the identification of valuable knowledge is a key concern. There is little point in the elicitation of knowledge that can be easily found online or in textbooks, journals, reports, *etc.* (Okafor and Osuagwu, 2006). The selection process is further complicated in rapidly changing domains, whereby elicited knowledge may become redundant even before it has been made explicit and distributed. Another issue is the confidentiality of knowledge. In domains such as the military, where experts in the field are subject to codes of confidentiality, organisations may be unwilling to create explicit knowledge, risking the loss of trade secrets, distributed to competitors by disgruntled employees.

An additional consideration is the availability of physical resources required to support the KE task. In the SECI model (section 2.3.3), Nonaka made reference to working spaces where the KE process can be performed i.e. "*Originating Ba*" (see section 2.3.2). Organisations must provide the physical tools (e.g. availability of meeting rooms, recording equipment, groupware, tools *etc.*) to facilitate the process. Without these the time taken in order to perform KE can be further lengthened.

3.3.2.21ssues in Selecting Appropriate Knowledge Elicitation Techniques

Over the past decade, the development of multiple techniques and methodologies that exist in the KE field has provided a basis for confusion. In selecting appropriate techniques for KE, Cooke (1994) stated that "no technique is guaranteed to result in a complete and accurate representation of an expert's knowledge". Selecting the right

techniques is an empirical and often iterative process. Whilst we cannot extract an experts knowledge in its entirety, these tools are capable of providing rich information relating to concepts, relations, facts, rules, and strategies relevant to the domain in question (ibid).

The selection of KE tools is based on the function that they fulfil (Cooke, 1994). The techniques differ in terms of their procedures, as well as their emphases on one type of knowledge or another. In selecting appropriate techniques, a knowledge engineer must be aware of techniques used in similar or related fields. In new domains, whereby previous case studies do not exist, the selection process is complicated. From the literature, we see that techniques are almost always used in collaboration with others, thus adding to complexity of technique selection.

Another consideration when choosing a KE technique is the use of a single expert or multiple experts. Using techniques such as interviewing in the knowledge elicitation of multiple experts can exponentially increase the cost to perform the KE activity.

Another factor that will impact the KE process is to determine whether the expert is articulate enough to express his knowledge as a clear set of modifiable facts, objects and rules, and give reasons for each decision. If not, appropriate KE methods must be sort. As we said that KE is a cost determining factor in KM initiatives, there is a need for fast KE techniques.

3.3.2.3 Issues With The Knowledge Elicitation Process

Once a Knowledge Elicitation activity is up and running, the task can be slow, inefficient, and frustrating for all participants. Stefik and Conway (1982) described the knowledge elicitation as a "necessary burden, carried out under protest so that one can get on with the study of cognitive processes in problem solving."

The complexity of the KE process can also impact the accuracy. Okafor and Osuagwu (2006) identify several key issues. The first is that experts tend to present an unbalanced picture of their knowledge. When asked to explain their knowledge, most

experts are tempted to present only procedural steps taken to achieve a task. Whilst this is useful, it is necessary to expose other aspects of knowledge such as the problem solving strategies, used to explain the decisions made at certain points in the process on presentation of relevant domain variables. The identification of goals and sub goals are also important in explaining why certain tasks were or were not performed as well as providing the expected outcome of each decision made.

Due to work pressures or fears (identified in section 3.3.2.1), experts present often insufficient knowledge during the elicitation process (Okafor and Osuagwu, 2006). This becomes apparent when responses are brief or when details are not exposed unless prompted by knowledge engineer. We detailed in section 3.3.2.1, some of the problems associate with the use of multiple experts. However, when fully immersed in the knowledge acquisition process, other problems arise. The use of multiple experts working at the same time in the elicitation process would most likely introduce conflict of ideas and opinions, making it difficult to synergise.

In respect to working with a knowledge engineer, Wilson and Holloway (2000) raised the important issues underlying knowledge elicitation process. The first is that experts can feel often nervous or intolerant of the process. This usually happens where the expert feels handicapped or insecure in giving the knowledge. When a knowledge engineer does use appropriate terminology, when interacting with an expert, this can lead to confusion on the part of the expert. A problem with most elicitation processes is that in addition to the capturing of valuable knowledge there is also a certain amount which is irrelevant with respect to the target audience or end-users.

3.3.3 Requirements For Knowledge Elicitation

As a means of developing the requirements for knowledge elicitation, we will address the issues identified in section 3.3.2.

3.3.3.1Requirements for Initialising the Knowledge Elicitation Process

In initialising the knowledge acquisition process, in section 3.3.2.1, we identified issues which impact the bandwidth. In order resolve these issues, the following set of requirements are required. The first task which must be performed is the identification of valuable knowledge. The goals and purpose of knowledge elicitation project must be firmly established by the knowledge engineer, the experts as well as the various organisational sponsors who provide the go-ahead for this process. This acts as a means of measuring the resulting knowledge which is captured within the process. It is critical that knowledge which is captured in this process is of benefit to the organisation and the target audience which KM initiatives aim to support. With the expense incurred in KM initiatives, it is imperative that the focus on the elicitation of essential knowledge.

In order to address the availability of expertise, relevant knowledge sources have to be identified relevant to goals of the KE process. Hanes and Gross (2002) noted that experts used in the process should either be recognised as an expert in the field and possess expertise in handling rare or infrequent events within the knowledge domain. Ideally in the case of building expert systems, experts should not be one that possesses expertise for system. Fear of being removed from the organisation, will impact an experts willingness to participate in such initiatives. In identifying expertise, KE sessions should be concerned with those who have either been identified as experts in their field through the works they have authored, or by direct interaction with managers within the organisation. Companies, which are already involved in KM activities, might have tools like company yellow pages, knowledge and skills databases which contain profiles of expertise referring to individuals within the organisation (Okafor and Osuagwu, 2006).

Organisations must encourage experts to participate in these activities. This can be achieved in several ways Slagle and Wick (1988). Management participation is essential. They are responsible for creating a cultural change management program required to aid all KM initiatives. In doing this, they must make the experts aware of the importance their contributions are to the KE process as well as provide a commitment to the project. Organisations can also encourage experts to participate through financial and statutory payoffs. In terms of their usage in the KE process, they must provide assurances that the time allocated to each elicitation session is kept to a minimum. Table 3.2 contains a full list of the essential and desirable features proposed by Slagle and Wick (1988), which results in the facilitation of the co-operation of experts in the KE process

ESSENTIAL FEATURES	DESIRABLE FEATURES
Recipients agree on high payoff	Management committed to follow on
Recipients have realistic expectations	Insertion into work place smooth
Project has management commitment	System interacts with user
Task is not natural language intensive	System can explain reasoning
Task is not knowledge intensive	System can intelligently question user
Test cases are available	Task identified as problem area
Incremental growth is possible	Solutions are expandable
Task requires no common sense	Task does not require real-time response
Task will be performed in the future	Similar expert system built before
Task does not require optimal solution	Task performed in hostile environment
Task not essential to deadline	Task involves subjective factors
Task easy but not too easy	Expert unavailable in future
An expert exists	Expert intellectually attached to project
Expert is a genuine expert	Expert does not feel threatened
Expert is committed to entire project	Expertise loosely organized
Expert is co-operative	
Expert is articulate	

Table 3.2 Table of essential and desirable features

In order to reduce the complexity of the knowledge management process, the selection of knowledge engineers is critical in minimising the problems of knowledge inaccuracies. Welbank (1983) identified a set of interpersonal skills required by a knowledge engineer. These include self-confidence, tact and diplomacy, and intelligence; versatility and inventiveness; empathy, patience and persistence. Not only are these 'soft' skills critical to the success of a KE initiative, the knowledge engineer should possess a working knowledge about the domain. An awareness of recent developments and an ability to be critical of the knowledge transferred is vital in order to elicit deeper understanding of concepts being exposed. As a means of reducing costs, the KE engineer must also be aware of the most appropriate KE techniques as well as ensuring that a common set of terms is put in place in order to facilitate the use of multiple experts from differing fields.

Finally in creating the right work environment, Organisations must make available the resources required in terms of resources and tools to facilitate the process.

3.3.3.2Requirements for Selecting Appropriate Knowledge Elicitation Techniques

It is the role of the Knowledge engineer to identify the appropriate tools, and the selection process is dependant on a number of factors. The use of case studies in the same or similar fields of research can provide the basis for selecting the right KE techniques to be employed in this process.

When working with a Single SME appropriate techniques can be employed to effectively assist (or scaffold) the KE process to effectively capture tacit knowledge. If an expert is articulate and willing to express their knowledge, direct methods of questioning can be employed. These methods include all forms of interviews, case studies, protocols, critiquing, simulation and prototyping, teach-back, observations, *et cetera* (Burge, 2001). Most often these methods elicit procedural knowledge. However, if the expert, in question, is relatively inarticulate, then more indirect methods can be employed. Methods (such as role playing, construct elicitation, card sorting, 20 questions, and document analysis, *etc.*) can be employed (Burge, 2001).

In terms of group analysis techniques such as focus groups, they can provide a means to facilitate the different perspectives around a problem. Despite the inherent problems of group dynamics, Massey & Wallace (1991) found that the use of focus groups can aid the generating original responses as well as individual interviews and were at least as good as individual interviews in terms of the quality and acceptability of ideas.

In order to keep the costs associated with KE to a minimum, KE tools aim to minimise the time spent with a SME whilst ensuring the quality of the knowledge elicited. In order to achieve this, the selection of appropriate KE techniques is a key factor in the success of KM initiative.

3.3.3.3 Requirements for The Knowledge Elicitation Process

As a means of supporting the knowledge elicitation process, the issues in section 3.3.2.3 must be addressed. In order to overcome issues concerned with the unbalanced picture presented by the experts, the knowledge engineer must keep the KE process focused on the goals established on the onset of the activity. This will eliminate the capturing of irrelevant knowledge. An effective KE session will encapsulate essential knowledge as well as identifying outliers such as exceptions and preferences.

As a means of negating the work pressures faced by the SME i.e. pressure to participate in KE sessions as well as the need to perform their primary function within the organisation, time must be allocated by management in order to help SME's to manage their work load.

And finally, to alleviate fears associated with the loss of key knowledge, the additional cultural change program must be reaffirmed during the process by the Knowledge Engineers in order to allay the fears of the SME during the KE process.

3.3.4 Knowledge Elicitation Techniques

Many techniques have been developed to help elicit knowledge from experts. In the literature, there exist many different categorisations. In the following section, we shall look at the various categories of KE techniques in order to gain an overview of when and how these techniques can be employed. As we will see these techniques do not sit neatly into a single category but often span multiple categories. From the literature, there have been various efforts made to classify KE techniques (Burge, 2001; Cooke, 1994; Cordingley, 1989). In section 3.3.4.1, we will look at the distinction between

direct and indirect methods. This will be followed by an overview of natural and contrived techniques in section 3.3.4.2. The selection of techniques used when dealing with single and multiple SMEs will be discussed in Section 3.3.4.3. This section will be concluded with a discussion of the types of knowledge obtained by KE techniques in section 3.3.4.4.

3.3.4.1Direct / Indirect Methods

The first categorisation, which we will look at is the distinction used in a study of knowledge elicitation techniques and subsequent analysis techniques performed by Olson and Biolsi (1991). In their paper, they divided the techniques in to two classifications, *direct* and *indirect* methods.

Direct methods refer to the KA methods that expose knowledge from the SME during a KE session. This can be achieved though interviews, whereby the expert articulates knowledge, or through observations, whereby the expert demonstrates their knowledge. In this categorisation, Olson and Biolsi (1991) identify a list of methods associated with this categorisation in table 3.3. Direct KA techniques offer the knowledge engineer the possibility to elicit various types of knowledge through direct access to the SME. However Olson and Rueter (1987) warn that typically the knowledge that will be uncovered with these techniques are generally declarative or surface knowledge. These methods will extract only what the expert is able to verbalize and overreliance on these techniques will exclude other forms of knowledge.

Category	Examples
Direct Techniques	Interviews
	Think-aloud
	Observation
	Interruption Analysis
	Commentary
	Drawing of Groupings in a Spatial Array
	Card Sorting

Table 3.3 Examples of Direct KE Methods

By contrast, *Indirect Methods* are defined as techniques whereby knowledge is inferred from the behaviour by the expert. The knowledge elicitation sessions are performed and retrospectively analysed in order to elicit the knowledge required. Olson and Biolsi (1991) identify a list of methods that are categorised as indirect, in table 3.4. These types of techniques, do not rely on the expert's ability to articulate the knowledge used. They collect other behaviours from which the knowledge engineer makes inferences about what the expert must have known to perform as he or she did. These may uncover a deeper (procedural or semantic) knowledge, but will involve assumptions about the underlying form of the representation employed by the expert. Therefore, these techniques could be misused to the extent that their basic assumptions are not supported by the data (Olson and Rueter, 1987)

Category	Examples
Indirect Techniques	Multidimensional Scaling
	Repertory Grid Analysis
	General Weighted Networks
	Ordered Trees from Recall
	Decision Analysis
	Machine Induction
	Hierarchical Clustering

Table 3.4 Examples of Indirect KE Methods

3.3.4.2 Natural and Contrived KE techniques

The next categorisation of KE techniques is the difference between natural and contrived techniques. Shabolt and Burton (1989) use this categorisation in order to differentiate KE techniques. *Natural Techniques* are defined as those which involve the expert doing tasks normally associated with the job they perform. These techniques allow insight to be gained naturally from the SME whereby knowledge can be articulated (e.g. interviews), demonstrated (e.g. observations) or demonstrated retrospectively through commentary (e.g. protocol analysis). Typically these techniques provide a mechanism for experts to reveal procedural knowledge about

their daily tasks. These techniques facilitate the elicitation process in a work environment, therefore minimising time taken out of the work environment. However they are limited in acquiring tacit knowledge and atypical knowledge. In order to facilitate this, KE is often used in combination with contrived techniques.

Category	Examples
Natural Techniques	Interviews
	Observation
	Group Meetings
	Questionnaires
	Protocol Analysis

Table 3.5 Examples of Natural KE Methods

Contrived Techniques are defined as those that an expert would not necessarily do as part of their everyday work. These techniques are generally derived from psychology. Techniques, such as card sorting and laddering, can be used to challenge an expert, thus exposing are their problem solving behaviours as well as revealing facets of knowledge (e.g. rules of thumb) developed through experience, working in the problem domain.

In performing a KE exercise, Shabolt and Burton (1989) recommend a combination of both. In table 3.6 contains a list of techniques with reference to their associated groupings

Category	Examples
Contrived Techniques	Card Sorting
	Triadic Elicitation
	Repository Grid Technique
	Constraint Tasks
	20 Questions
	Commentary
	Teach Back

Table 3.6 Examples of Contrived KE Methods

3.3.4.3 Individual and Group Knowledge Elicitation

This categorisation pertains to the KE methods, that are used in isolation with a single SME and those that are used in conjunction with multiple experts. Research in knowledge elicitation typically focuses on techniques based on the use of a single human expert. The majority of techniques in the literature fall into this category. Moore & Miles (1991) noted that the use of single expert normally occurs by default, as opposed to a conscious selection choice. The use of a single SME in knowledge elicitation, limits its scope i.e. the KE process is restricted to the size and complexity of the domain of an expert's knowledge (McGraw & Seale, 1988). The absence of multiple experts in the KE process also impacts the ability of KE process to fill gaps that exist in an expert's knowledge (Mittal & Dym, 1995). As seen in section 3.3.2.1, access to a single expert, particularly those critical to an organisations primary function, is severely limited. Another limitation of single expert KE is that the reliance on the expertise of an individual does not accurately reflect the actual decision making process, in which, organisational decisions are made through consultation with multiple stakeholders (McGraw & Harbison-Briggs, 1989).

In order to address these issues, there are several KE techniques which aim to foster the opinions of multiple experts. Table 3.7 contains a list of techniques used in the elicitation of group knowledge. In dealing with groups of experts, there are several difficulties associated. In section 3.4.3.1, we made reference to the issues of identifying and selecting of expertise for the KE process. Techniques can also be limited in terms of the number of participants which can be involved in the KE process. The number of experts must be large enough to ensure coverage of the domain, whilst small enough so that the process can remain manageable (McGraw & Seale, 1988). Dealing with groups of individuals will, almost always, result in some form of conflict of opinion. In order to facilitate group KE techniques need to incorporate some form of conflict resolution and consensus mechanism, be it the judgment of the knowledge engineer or the use of a voting system (Turban and Tan, 1993).

Category	Examples
Multiple Domain Experts	Focus Groups
	DeBono's 6 Hats of Thinking
	Concept Maps
	PMI

Table 3.7 Examples of Multiple Domain KE Methods

3.3.4.4 Types of Knowledge Obtained

Another grouping of knowledge elicitation techniques used by Burge (2001) to categorise KE techniques is by the type of knowledge elicited. In this categorisation, Burge identifies six categories, procedures, problem solving strategy, goals and subgoals, classification, relationships and evaluation. As with individual and group knowledge elicitation techniques, KE techniques often fit into more than one category. From this we can deduce that specific KE techniques can elicit more than one type of knowledge.

The first categorisation is procedures. Techniques in this category can be used to elicit procedural knowledge (discussed in section 2.2.2.3). Burge (2001) defines these types of tools as those "used to determine the steps followed to complete a task and the order in which they are taken". Table 3.8 contains a list of examples of techniques used in this categorisation of KE techniques.

Category	Examples
Procedural Techniques	Interviewing (structured, unstructured, semi-
	structured)
	Concept Mapping
	Interruption Analysis
	Questionnaire
	Teach back

Table 3.8 Examples of KE techniques for Procedural Knowledge

The next category is the set of KE tools which are used to elicit a problem solving strategy. Techniques in this category can be used to elicit semantic and episodic knowledge (discussed in section 2.2.2.3). These methods aim to elicit knowledge pertaining to the strategies employed by an expert in their decision making processes. Table 3.9 contains a list of examples of techniques used in this categorisation of KE techniques.

Category	Examples
Problem Solving Strategy Techniques	Interviewing (structured, unstructured, semi-
	structured)
	protocol analysis (think
	aloud, talk aloud,
	retrospective reporting,
	behavioural descriptions,
	playback)
	Commentary
	20 questions

Table 3.9 Examples of KE techniques for Problem Solving Strategic Knowledge

The following category refers to techniques that elicit knowledge pertaining to goals and sub-goals. These techniques are used to decompose tasks being performed by an SME during a KE session. Techniques in this category are used to elicit procedural knowledge (discussed in section 2.2.2.3) but Burge (2001) distinguishes these methods from the ones found in the procedural section since ordering of goals / sub-goals are not necessarily provided. Table 3.10 contains a list of examples of techniques used in this categorisation of KE techniques.

Category	Examples
Goals / Sub-goals Techniques	Critical Decision Method
	Task action mapping
	Re-classification
	Goal Decomposition

Table 3.10 Examples of KE techniques for Goals / Sub-Goals Knowledge

In Classification, the KE techniques are used to classify entities within the domain. Techniques in this category are primarily used to elicit declarative knowledge (discussed in section 2.2.2.3). Table 3.11 contains a list of examples of techniques used in this categorisation of KE techniques.

Category	Examples
Classification Techniques	Distinguishing goals
	Decision analysis
	repertory grid
	laddered grid
	Triadic elicitation

 Table 3.11 Examples of KE techniques for Classification Knowledge

The next category relates to the knowledge found in dependencies / relationships. In this category techniques are used to obtain relationships between domain entities. Techniques in this category are used to elicit semantic knowledge (discussed in section 2.2.2.3). Table 3.12 contains a list of examples of techniques used in this categorisation of KE techniques.

Category	Examples
Dependencies/Relationships Techniques	card sorting
	Triadic Elicitation
	Discourse analysis
	(observation)
	Semantic nets

Table 3.12 Examples of KE techniques for Dependency / Relationship Knowledge

The final set of KE techniques are used to evaluate systems, usually prototype systems, or other types of KE session results. The final set deal with qualitative metrics. Table 3.13 contains a list of examples of techniques used in this categorisation of KE techniques.

Category	Examples
Evaluation Techniques	Teach Back
	Critiquing
	Decision analysis
	Rapid prototyping

Table 3.13 Examples of KE techniques for Evaluation Knowledge

3.3.5 Knowledge Elicitation in Knowledge Creation

At the start of this chapter, reference was made to the fact that knowledge elicitation is a subset of knowledge acquisition which in turn is a subset of Knowledge Creation. In order to illustrate this relationship, the following section looks at how KE can be incorporated into the creation of knowledge. Based on the Bechhofer (2006), we will look at the formal performing the steps of Knowledge Creation with reference to the steps in which Knowledge Elicitation plays an important role. Conceptual Modelling and Software engineering share some characteristics such as requirements capture, specification, implementation, and evaluation (ibid). The following will look at these steps, emphasising the role of KE.

3.3.5.1Establish The Purpose, Scope, and Requirements Of Knowledge Capture

When implementing a Knowledge Creation Initiative, the first step is to establish the goals and the sub-goals of the project. This task involves setting a high level overview of the project's scope. Identifying the need for the project as well as getting a clear picture how the initiative aims to align itself with the company strategy. Alignment of KM initiative to the corporate strategy is an important factor to the success of a project. If an initiative can be directly linked to a tangible benefits (e.g. cost saving, increase revenue, *etc.*) or a non-tangible benefit (customer satisfaction, phone call averted, *etc.*), it will be well received within the organisation (De Long *et al.*, 1997).

The key stakeholders required to get the project off the ground will also be established at this point. This task will involve input not only from the sponsor and the program manager but also from the technical staff as well as the staff whose needs will be addressed by the Knowledge Creation process. KE Group techniques identified in section 3.3.4.3 can be used in establishing the purpose, scope and requirements as well as a project plan. Once created and signed off by all participants, the KM Initiative can proceed. Without the purpose, scope, requirements, and plan, the success of an initiative cannot be adequately evaluated.

3.3.5.2 Implementation

The next step is the collection of terms pertaining to the objects that exist within the problem domain. Terms can be collected informally by a knowledge engineer or formally in co-operation with experts in the field. Informally these terms can be acquired indirectly from existing knowledge artefacts (e.g. Documents, Manuals, Web resources, *etc.*). Formally they can be collected directly using interviews with the experts or through the use of techniques such as classification techniques such as card sorting and laddering techniques. This step is used to clarify terms as well as produce informal concept definitions, forming the basis of the terms which will be used during the interactions with the knowledge engineer and the expert(s).

Once the common terminology has been established, the next step is an iterative process in which, Knowledge Engineers and Experts work together in order to establish relationships between the various concepts are identified as well as identifying entities which can exist on their own. Modifiers, such as adjectives and adverbs that exist in the domain, are also identified. This set of concepts pertains to the terms that can modify the sub-domains concepts. Contrived techniques such as triadic elicitation and 20 questions can help to determine the important characteristics which can help in the establishing of relationships between entities.

In order to assist the elicitation process, normalised schemas and skeleton schemas can be used to keep track of the knowledge being elicited as well as providing a mechanism whereby knowledge from each session can be compared. This phase is important as it can provide feedback into the creation of the initial requirements, which in turn provides a mechanism for refinement of requirements as well as the evaluation criteria for the Knowledge Creation initiative.

3.3.5.3 Knowledge Representation

Once the required knowledge has been elicited, the knowledge can be represented. There are formal mechanisms that can by used to formalise this e.g. writing definitions in FOL or OWL or defining frames.

3.3.5.4Evaluate & quality assure

Once the elicitation and representation has been performed, they can be assessed against the goals which have been established at the onset of the knowledge capture initiative. The conceptual models developed from the KE exercises can help validate the processes used to build the model as well as ensuring that KE is principled and well documented.

3.3.5.5 Monitor use and evolve

On completion of the knowledge capture process, lessons learnt provide an important feedback mechanism in improving the process. In terms of knowledge elicitation, the creation of case studies based on the positive and negative aspects of the process can greatly improve the KE process and dictate the course of future activities.

3.4 Conclusions

In this chapter, we defined of knowledge acquisition looking at the various subsets of the subject as well as the issues which affect each type in the acquisition of knowledge. From this our focus shifted to the subject primarily concerned with the elicitation of knowledge from a human expert, known as knowledge elicitation. An overview was provided of the area, looking at the various influences which have directed research in the area. The issues and requirements for KE were addressed. We looked at various classifications of KE and finally identified the use of KE in terms of the knowledge capture process (identified in section 2.4.5.2).

To put this chapter in the context of the thesis, we are concerned with acquiring knowledge (section 3.2) from a human source i.e. knowledge elicitation (section 3.3). For this task we will be using manual techniques (section 3.2.2.3). We aim to minimise the issues of the knowledge acquisition bottleneck (section 3.2.1) as well as the issues which pertain to knowledge elicitation (section 3.3.2) by focusing on the requirements for knowledge elicitation established in literature (section 3.3.3). The selection of KE techniques will examine both direct and indirect methods (section 3.3.4.1), natural and contrived (section 3.3.4.2), focusing on the use of techniques which elicit knowledge from a single domain expert (section 3.3.4.3). For the purpose of our knowledge elicitation, we will focus on techniques that elicit procedural knowledge (section 3.3.4.4) in order to encapsulate the knowledge required to perform techniques in mixed martial arts.

4 MIXED MARTIAL ARTS

"Since the UFC came around, martial arts have evolved more than they have in the last 700 years. We know exactly now what works in a real live situation with two warriors fighting."

Joe Rogan

4.1 Introduction

In this chapter we aim to provide an overview of the sport and research that exists within of Mixed Martial Arts (MMA). In section 4.2, we will look at the evolution of the sport and its impact on the Irish MMA community. In section 4.3, we will examine an Irish MMA organisation, Team Ryano in Baldoyle and see how knowledge is used extensively throughout its organisation.

4.2 Evolution of Mixed Martial Arts

The modern inception of Mixed Martial Arts (MMA) is relatively new. The past 20 years has seen the sport rise from its humble beginnings to wide spread acceptance as a legitimate sporting activity. In this section, we aim to put into perspective the rapid evolution of the sport on a national and international level. In section 4.2.1, we will provide a historical overview of the sport. We will look at the various criticisms of the sport (section 4.2.2) and how they have influenced MMA as we know it today (section 4.3.3). In section 4.3.4, we will look at look at the various strategies of Mixed Martial Arts and how they help define the sport. The section will be concluded by looking at the community that exists in Ireland today (section 4.3.5).

4.2.1 Historical

The field of Mixed Martial Arts can be traced back to the ancient Greek sport of Pankration; literally meaning "the one who has power" or "the one who wins with

total power and knowledge" (IFP, 2009). The sport combined elements of boxing, wrestling and kickboxing. It highly regarded and was one of the original sports of the Olympic Games. Ancient Greek philosopher, *Philostratos* in his *Gymnasticus* described the sport as *"the most exciting and worthiest of all sports in ancient Olympia*". The sport remained an integral part of the ancient Olympics until 393 A.D. when the games officially ended.

The modern revival of the sport can be dated back to mid-twentieth century, where the sport of Mixed Martial Arts grew out of the Brazilian combat sport known as Vale Tudo (a Brazilian term meaning "anything goes") (Hopton, 2007). This sport eventually made its way to the United States and was marketed under the name "Ultimate Fighting Championship" (UFC) by Semaphore Entertainment Group (SEG) spearheaded by businessman Art Davie and Brazilian Jiu-Jitsu pioneer Rorion Gracie. The first event was promoted on November 12, 1993 in Denver, Colorado and featured competitors from a wide and diverse range of martial the arts, such as sumo wrestling, kickboxing, traditional boxing, Kung Fu and Brazilian jiu-jitsu. The event centred on a 16 man knockout tournament with the eventual winner receiving a cash prize totalling \$50,000 (Mayeda & Chin, 2008). The use of a traditional ring was removed in favour of a more imposing caged octagon structure, which added to the mystique surrounding the event. The rules were simple; with the exception of biting and eye gouging, anything was permissible (van Bottenburg & Heilbron 2006). The UFC provided a source for confusion in its marketing their product (Hopton, 2007). On one hand, the events were promoted as a test to determine which martial art was most effective in a fight with few limitations and aimed to challenge the mystique built around some oriental martial arts. Whilst on the other hand, it was unashamedly promoted as a violent spectacle. The first UFC was won by the smallest competitor, a Brazilian jiujitsu practitioner Royce Gracie (brother of promoter Rorian Gracie). The event proved extremely popular on pay-per-view, with 80,000 people paying to watch the event from their home (van Bottenburg & Heilbron, 2006). This success led to UFC promoting more events and saw the creation of rival events not only in the US but also around the world (Bolelli, 2003). By the time the first MMA events were staged in the UK around 1997, more rules were in place to protect the fighters than had been seen in the early Ultimate Fighting Championship events (Hopton, 2007). However, the sport

suffered from the poor image promoted by the original owners of the Ultimate Fighting Championship, SEG.

4.2.2 Criticisms of Mixed Martial Arts

In the late 1990s and early 2000s, the sport went through a radical change. Whilst the sport ascended in popularity, the barbaric nature in which it was promoted drew the attention of politicians such as Senator John McCain. McCain led a campaign to ban UFC and sent letters to the governors in all fifty U.S. states asking them to ban the event, as a result thirty-six states passed laws that banned "no-holds-barred" fighting (Plotz, 1999). Despite working with state athletic commissions to review the rules surrounding MMA, the UFC franchise was eventually sold by SEG to Zuffa Entertainment. With change of ownership, the UFC aimed to immediately rectify the tarnished image of the sport. In order to legitimise MMA as a sport, they produced a comprehensive list of rules and had them approved first by the New Jersey State Athletic Commission and then later by the Nevada State Athletic Commission (Meyeda & Chin, 2008). These rules form the basis of what is now known as the Unified Rules of Mixed Martial Art (Appendix A). Included in these rules were the introduction of time-limited fights, five minute rounds, protective gloves, judges for fights that "go the distance" and an increase in the number of fouls. (Hopton, 2007). These rules were later adopted by other MMA promoters both in the USA and the UK (Gentry, 2002).

4.2.3 Maturity of Mixed Martial Arts

Over the past five years, MMA has steadily gained widely acceptance by the general public. The international expansion of the MMA can be attributed to the efforts of Zuffa Entertainment, the owners of UFC. One such initiative was the self-produce MMA reality show, "*The Ultimate Fighter*", which consisted of sixteen fighters competing for a six-figure UFC contract. The series was globally distributed to 100 markets and helped change public perception of the athletes who competed in MMA from "*crude thugs*" to "*great athletes, intelligent and with good manners*."

(Grossekathofer, 2008). The UFC roster has included a set of diverse fighters from fields as varied as psychology, education, politics (i.e. Mirko Cro-Cop a former member of the Croatian parliament) competing against high calibre athletes with more traditional athletic backgrounds such as Olympic medallists and former collegiate wrestling national champions. (ibid)

From a business perspective, MMA has gone through rapid change. In 2006 the UFC exceeded boxing and wrestling in the pay-per-view world, grossing more than \$222 million (Beato, 2007). The "*UFC 75*" pay-per-view drew 5.6 million viewers (UFC, 2007). In 2007, seven of the top ten pay-per-view events in the United States and Canada combined (in terms of revenue) were UFC promotions.(Schneiderman, 2008). It is estimated that the UFC is now valued at \$1 billion (Grossekathofer, 2008).

The sport's popularity, and the increased understanding of the sport itself, has led thirty-six of the forty-four states with athletic commissions to officially recognize and regulate MMA (Hunt, 2008). Former foes of MMA who have followed the sport through its various reforms, now view it as a legitimate sporting contest. John McCain has been quoted as saying, "*The sport has grown up. The rules have been adopted to give its athletes better protections and to ensure fairer competition*" (Davies, 2007). Later that year, McCain's home state of Arizona legalized MMA and began regulation of the sport.

4.2.4 Strategies in Mixed Martial Arts

Mixed Martial Arts (MMA) is a multidisciplinary full contact sport. The sport has evolved from its inception by incorporating different aspects of other combat sports, which have been empirically tested in MMA competition. The philosophy of MMA is very simple and has much in keeping with Bruce Lee's ethos, described in his seminal work "*The Tao of Jeet Kune Do*", in which he states "*Use only that which works, and take it from any place you can find it*" (Lee, 1975).

In the evolution of the sport, there have been various combat sports which have heavily influenced the techniques which are employed. In the early MMA events, the grappling arts such as Brazilian Jiu-Jitsu (BJJ) and Olympic Wrestling sport heavily influenced the sport. These sports exposed the limitations of purely striking arts such as Boxing, Tae Kwon Do, Kung Fu and Karate. Fighters from these arts were easily taken down to the ground using takedowns or throws. As these techniques were not performed as part of their regular training, practitioners were unable to defend against them. Once on the ground, grapplers would then work to attain a dominant position in which submission holds (traditionally used in sports such as BJJ, Judo, Sambo and Shoot-Wrestling) could be applied, forcing their opponents to submit. This strategy was popularised in the early UFC events by BJJ practitioner Royce Gracie and Shootwrestling practitioner Ken Shamrock.



Figure 4.1 Royce Grace performing an Armlock at UFC 2

Although the early UFC events were characterised by the effectiveness of grappling, the sport later evolved in another direction, where practitioners from the striking arts started to employ strategies that negated the tactics of the grapplers. One such tactic was known as anti-grappling. Anti-grappling involved the use of techniques that either prevented a striker from being taken to the ground or if taken to the ground, enabled them to get back to their feet as quickly as possible, without significant damage being absorbed in the process. Ironically most of these techniques find their roots in the grappling arts. Early proponents of this strategy included Maurice Smith, a former professional kickboxing champion. He used this strategy to great effect in his match

against previously undefeated former National Collegiate Athletic Association (NCAA) wrestling champion, Mark Colman at UFC 14.



Figure 4.2 Anti-Grappling defence

Over the years, many other strategies have been created. All of which, seek to address the problems associated with other strategies. Whilst the techniques find their roots in traditional martial arts, it is high-level strategies that are the ones which are unique to the sport of Mixed Martial Arts. Today's modern mixed martial artists not only embrace techniques taken from various fighting disciplines, but also have to employ the strategies in MMA. Fighters who are unable to successfully combine these are at a distinct disadvantage.

4.2.5 Mixed Martial Arts in Ireland

The past 10 years has seen the sport of Mixed Martial Arts flourish in Ireland. The first clubs in Ireland were established circa 2000 mainly in the Dublin and Belfast area. Later groups were established in other parts of the country as far afield as Cork, Galway, Limerick and Donegal. Initially these clubs operated more as a collective in which individuals from various backgrounds (such as Kenpo Karate, Judo and Japanese Jiu_Jitsu) would learn from each other with the goal of competing in MMA competition (Kavanagh, 2000). This is very much in keeping with the Choo's notion of sense-making (detailed in section 2.3.2). In addition to the cross-training, the early

Irish proponents travelled to the UK, USA and Brazil to learn their craft. These skills were brought back to Ireland, absorbed by the community. Another important way in which their training was supplemented was through the use of video and instructional tapes acquired from the US. These tapes helped the MMA community learn from second-hand sources the techniques and strategies used in the sport (Jones, 2010).

Almost from the inception of the sport in Ireland, internet-based communities of practice were established. This enabled people with a common interest in the sport located nationwide to exchange ideas and techniques. Due to its proximity to Ireland, most Irish-based competitors were found interacting on the UK-based forums, such as the SFUK and Cage-Warriors forums. Later Irish-based communities were established on internet-forums such as, Irmac.net and Boards.ie, which aimed to serve the sharing of knowledge specific to the Irish MMA community.

The first MMA events in Ireland were held in the same year. Eager to test their skills, the practitioners took part in MMA contests. These fights took place in old boxing rings and on Judo mats. As no Irish governing body existed, the rules were left at the discretion of the promoters and participants. In order to prepare fighter for professional level competition, amateur events started to appear. The first nationwide amateur competition was the MMA league in which professional rules were modified in order to ensure the safety of the novices (Appendix B). This event and other similar events helped to elevate the level of MMA in Ireland by giving the practitioners a way to test and hone their skills in competition. The success of this event later saw the introduction of a woman's divisions and teen divisions.

An unlikely source of development of the sport in Ireland came from its immigrant population. As Ireland experienced a growing prosperity at the end of the last decade of the 20th century, the influx of Polish and Lithuanian workers also attributed to the rise in popularity of the sport. As the sport of MMA was taking off in Ireland, a similar rise in popularity was being experienced in Eastern Europe. MMA clubs were being setup in Ireland by members of the foreign community. More and more non-Irish national competitors were eager to participate and started to appear in amateur and professional events.
As interest grew, more professional events started to take place. In Belfast, the Cage Wars promotion was established and in Dublin, members of Straight Blast Gym and Team Ryano began to promote its Ring of Truth events. Whilst early attempts to create a governing body all ended in failure, promoters agreed to the introduction of a classification of rules based on the Unified Rules of Mixed Martial Arts (Appendix A). Table 4.1 contains a list of the categorisations.

Classes	Differences from Unified Rules
Α	Full unified MMA Rules
В	No Elbow Strikes on the ground
С	No head strikes on the ground
D	No head strikes whatsoever

Table 4.1 Irish MMA Rules

In 2007, the UFC embarked on its international expansion and Ireland was one of the first countries selected to host their events. The first event, UFC 72, took place in June, 2007 at The Odyssey in Belfast and featured two Irish fighters who had participated on the national circuit, Stevie Lynch and Colin Robinson. The next event, UFC 93, took place in Dublin in January, 2009 and featured another Irish fighter, Tom Egan, who had also risen through the ranks of Irish MMA.

These two high-profile events saw the growth, rapidly accelerate. New MMA gyms have emerged throughout the country whilst established gyms have seen a surge in membership (Barry, 2009). The growth also fuelled a significant increase in the number of competitors participating in amateur events in Ireland. In 2008 there was the largest turnout to date at the Dublin leg of the MMA league with a total of 90 participants competing in the Dublin leg of the MMA league. This was later exceeded the following year where 130 fighters competed.

Today there are over thirty MMA gyms operating in Ireland. They provide coaching for their athletes as well as supply MMA events with competitors. There is a fear that some MMA organisations have been established to cash in on the popularity of MMA (Jones, 2010). Although the more established gyms are now affiliated to large international organisations. This association has benefited Irish MMA in many ways. Through these larger entities they have been given access to experts in the field. Over past few years, seminars have been conducted by current and former MMA competitors such as Chris Brenan, Ian Freeman, Royce Gracie, B.J. Penn, Marcus Davis, and Sammy Schivo.

Today more than ever, Irish participants travel far and wide to learn and compete in MMA competitions. Neal Seery, a member of Team Ryano in Baldoyle won the British Flyweight championship at an event in London. Greg Loughlan competed in a US based Bellator Fighting Championships in Florida. Although the sport is predominantly male-orientated, there are also female competitors participating in the sport. Making her professional debut in May 2007 at an MMA event in Denmark, Aisling Daly has amassed an MMA record of 9-0 and is ranked number four in the world at super-fly weight (UWMMA, 2010).

4.3 Team Ryano

Team Ryano is a full-time martial arts gym in Baldoyle, Dublin. Andy Ryan, who is a 4th Dan black belt in Judo, a brown belt in Brazilian Jiu-Jitsu (BJJ) and former MMA competitor, started the gym in 2005. The club not only provides classes in MMA but also has regular classes in BJJ, Submission Wrestling and Thai-boxing as well as providing women only and kid's classes in fitness, BJJ and Judo. Knowledge is a key asset extensively used in all aspects of its business. The skills required to perform and teach these various skills requires a deep understanding of all these various activities. At an organisational level, knowledge is required in the co-ordination of these activities. To illustrate the complexity of the organisational knowledge, the following section takes an in-depths look at the various entities that exist within Team Ryano

4.3.1 Individual

As with any organisation, Team Ryano is comprised of individuals. At a high level, we can divide these individuals into three distinct categories, students, instructors and the head coach.

4.3.1.1 Students

The first categorisation of individuals is the students. The primary service provided by Team Ryano is the teaching of martial arts. Students go to Team Ryano for a variety of reasons; some use the club as means to improve their fitness, others see martial arts as a way to build self-confidence, from the skills acquired at the club, and there those who are interested in learning more about the sports offered by the organisation, whilst others are keen to compete in the sports.

In learning the sport, students are initially engaged in a traditional apprenticeship-type learning experience detailed in section 2.3.1, in which the instructors are responsible for the coaching of the students. The students learn through observing the techniques and strategies being demonstrated. Once they have sufficient understanding, these techniques are then practiced. As the student develops, they can supplement their acquisition of knowledge through active participation in competitions, internalisation of knowledge artefacts or through the socialisation process with other practitioners (discussed in the SECI model in section 2.3.3).

Through practice and application of these skills, student progress in their competency of these skills. They gradually develop the characteristics identified by Chi (2006) in section 2.3.1.1. They adopt the best practices in generating the best solutions to problems under the time restrictions imposed by the dynamic nature of the sport. They are able to detect and recognise typical and atypical scenarios in which techniques and strategies can and cannot be employed. Highly skilled students know their own

strengths and limitations, and use this knowledge to best effect. With practice, they learn to employ complex techniques with minimal cognitive effort.

For the most part, the knowledge of the individual resides tacitly in terms of the techniques and strategies used in the sport. Expert students would have significantly deeper knowledge not only of the techniques and strategies but also the rules under which the sports are played as well as knowledge about the sport itself (e.g. the major players involved in the sport, win loss statistics on individuals, *etc.*). In terms of explicit knowledge, some students have: notebooks that contain the techniques of previous lessons; videos of competitions; sport-related books as well as instructional videos related to the sport.

In keeping with Bennet's Depth of Knowledge Taxonomy (detailed in section 2.2.2.2), novice students usually have some surface knowledge of the sport before they start but it is not until they start participating that they gain shallow knowledge which would then leads to deeper understanding of the sport. As students progress in the sport, proficiency scales can be used to validate an individual's knowledge depending on the sport being played which is not uncommon in martial arts. The BJJ group uses a proficiency scale that is validated by the international organisation BJJ Revolution. In MMA, there is no formal scale used but there is a demarcation between novice and senior students, in that senior students either have years of experience in the club or they have competed in formal competition.

Whilst some students participate in the sport for long periods of time, the physical nature and the time required in terms of practice sees students leave the organisation for a variety of reasons. Injuries are common place in practicing and competing in martial arts. Time restrictions placed on the individual from work and personal relationships can impact an individual's commitment to practice. Others simply lose interest in practice, due to a lack of progression or an attainment of personal goals.

4.3.1.2Instructors

The next category of individuals in the organisation is its instructors. As students progress, eventually they get to a point where they have attained expertise in the skills of the various sports, discussed in section 4.3.1.1. One of the next options open to them is to use their skills, in a teaching capacity, as an instructor. There are several reasons why individuals become instructors: some see it as a way of giving back to the martial arts community knowledge which they have acquired over the years; others see this as a means to supplement their income. Although the financial rewards are relatively low, it can provide a means of covering the costs incurred through training (e.g. costs of lessons, equipment, travel to events where they compete). Whilst some teach within the organisations, some former students have set up their own clubs (e.g. Xtreme Fighting Ireland, Rush Fight Academy, DCU MMA club, ITB MMA club).

The instructor's knowledge generally exceeds that of a student. It is not only skills in martial arts that are required to be a good trainer, but coaching skills are also essential too. In a review of the Ladies Professional Golf Association's (LPGA) top 100 expert golf instructors, Schempp (2000) identified two characteristics that identify an expert teacher, the first was playing experience and the second was teaching experience. Schempp noted that the majority of instructors used in the study had extensive playing experience, but most started at an early age. Their playing experience was not only extensive, but also successful, most having had success at regional, national, and professional level. In terms of the experience of teaching, he noted in the survey that the golf teachers had on average almost 17 years of experience.

A pre-requite for teaching is a deep knowledge of the system in which they teach. A teacher's proficiency can be ascertained though the grades used by the students and the teaching qualifications in the sports of Judo and BJJ. However in teaching MMA and boxing, this either comes through years of participation or the years teaching students to participate in the events. Typically the teachers would have deep knowledge of the procedural, declarative, semantic and episodic knowledge of the sport being covered.

In order to prepare instructors, Team Ryano provides an informal "*train-the-trainer*" course. This course is run by the Team Ryano head-coach, Andy Ryan, in which he helps develop the teaching skills of novice and experienced trainers by providing a

general curriculum for the teachers to follow as well as teaching techniques that aim to develop the skills of the students. His philosophy has much in common with the traditional apprenticeship model, detailed in section 2.3.1, in that techniques are demonstrated, coached and eventually practiced. The training also addresses other skills such as ensuring the safety of its participants, physical conditioning, considerations when teaching children's classes, *etc.* Whilst there are no formal proficiency scales, used in the teaching of MMA, the clubs affiliation to BJJ Revolution means that BJJ coaching certification can be attained in Ireland. The boxing and the Thai-boxing teaching certifications outside the Team Ryano's primary affiliations.

As with students, most of instructor's knowledge resides tacitly. Knowledge in the instructor not only pertains to the skills required to perform the techniques and employ the strategies of the specific discipline, but also in terms of the knowledge required to teach. This includes knowledge of the students as well as how they interact in practice e.g. knowledge of individual's strengths and limitations, methods in which individuals can be challenged, *etc.* Explicitly, the instructors would have similar artefacts to that of the students, although they sometimes have additional teaching resources not normally used by the students.

As with students, instructors can either stay with the sport varying periods of time. There is more commitment required for instructors however with financial rewards on offer from participation helps some instructors to fully immerse themselves in the sport. Currently in Ireland there are some twelve full-time instructors involved in the sport and as the popularity of the sport continues to rise, this figure is likely to increase.

4.3.1.3 Head Coach

The role of head coach at the Team Ryano organisation is Andy Ryan. At Team Ryano, he is not only responsible for delivering the courses on offer but he has additional responsibilities in overseeing the running of the club. The title is misleading

in that it does not fully encompass the totality of the tasks for which he is responsible. He runs the club on a full-time basis and is therefore responsible for the provision of the physical spaces required to perform the activities but he is also responsible for attracting new members as well as addressing the needs of the students through the provision of coaching staff.

Andy Ryan is not only a business man; he is very enthusiastic about the sports provided by the organisation and is very hands-on in the coaching of the sport. From his vast practical experience, Andy has developed deep knowledge of not only participation but also coaching and running a fulltime business. Most of his knowledge resides tacitly. He started practicing Judo at the age of six years old. In his years in the sport, he participated in the Irish National Judo championships at junior and senior levels, receiving ten gold medals at senior level. At international level, Andy has represented Ireland, competing in international competitions. During his time participating in Judo, he coached various teams in Dublin as well as the Irish Blind Sports Judo team for four years.

He became involved in MMA and BJJ in 2001 at the Full Circle Gym in Dublin (which later went onto become Straight Blast Gym Ireland), receiving his BJJ blue belt in 2002, his purple belt in 2006, and his brown belt in 2009. Between the years of 2001 and 2006, Andy competed in various MMA events both nationally and international. In 2005, he founded the Team Ryano gym (initially in Finglas) and began teaching BJJ, MMA and submission wrestling. He eventually retired from active MMA participation and started concentrating on coaching full-time in 2006. Although retired from MMA competition, he still regularly competes in international BJJ competitions, recently winning gold in the 2010 European BJJ brown belt masters level divisions in both heavyweights and open weight categories. In terms of coaching, his students over the past five years have participated nationally and internationally at a variety of levels in both BJJ and MMA competitions. He is also responsible for teaching some of the top coaches in the country including Wayne Fagan, Paul Cowzer, and John Donnelly.

4.3.2 Groups

In addition to the coaching, the organisation benefits from the collective knowledge of the group. Learning martial arts in traditional and mixed martial schools is as much a collaborative effort as an individual one.

The gym consists of five groups, the BJJ group, the Submission Wrestling group, the Thai-boxing group, the Judo group and the boxing group. In these groups, students learn techniques and strategies that are specific to each one. Most of the students who go to Team Ryano participate in more than one, however for the most part the instructors are sport specific to the groups. Whilst it is not so prevalent with senior students, there is a danger that novice students try to employ techniques and strategies that are ineffective in situations in the other sports. Individuals who learn within the group benefit from the collective knowledge available within the group. Group participation offers students additional avenues in which knowledge can be acquired, which is in keeping with Nonaka's theory of socialisation (section 2.3.3). In additional to the coaching of the instructors, knowledge can be acquired from other students, who might greater experience in the different facets of the sport.

As we have seen so far, tacit knowledge is the primary source of knowledge within the organisation. It exists in the techniques and strategies employed by its participants as well as the various relationships that exists between the organisations individuals. An example of group knowledge is in the selection of people they train with. Senior students tend to train together as they have similar levels of experience. By participating with other students at the same level, they can learn from each other and yet remain competitive in practice. There also exists knowledge of group etiquette, in which hygiene must be considered when participating in certain sports, for example the cutting of toe nails when performing BJJ. Explicit knowledge also plays a role in the organisation. Knowledge artefacts are frequently exchanged between individuals such as books and videos, containing sport specific knowledge.

As the groups develop, pre-requisite knowledge of procedural, declarative, semantic, and episodic becomes ingrained in its groups members. As the groups develop, so does the terminology being used by the individuals. Terms are created relating the ideas and concepts previously discussed that act as a means of creating a level of abstraction on which high-level concepts can be discussed. The maturity of the group is characterised by the deep level of knowledge that exists within the collective and is demonstrated in the success members of the groups have had in national and international competition.

4.3.3 Organisational Level

Although it is difficult to separate the coaching side from the organisational side, there is knowledge that is specific to organisational matters. As we made reference to section 4.3.1.3, the head coach is also the head of the organisation. He is not only responsible for overseeing the teaching; he is responsible for operating the gym as a business so that it can continue to operate. As with any organisation, Team Ryano suffers from loss of organisational knowledge when both students and coaches leave. In order to support the core activities of the organisation, the organisation is responsible for attracting attract new students and coaches to club as old ones leave.

At an organisational level, the coaching of students is not an immediate concern. To provide the best training for its athletes, Team Ryano must find and financially support experienced teachers. The provision of these coaches is usually on a part-time basis and the organisational is also responsible for ensuring these coaches have the pre-requisite skills. The organisation is responsible for supporting the various groups. Team Ryano, as well as arranging the training schedule, provides training seminars with leading figures in the field. For example, in the BJJ group, they have organised seminars from current and veteran BJJ competitors such as Carly Gracie, Arthur Ruff, and Rodrigo Maderios.

Most of this knowledge is tacit knowledge, however over the past few years they have started to develop explicit knowledge. One such activity is the provision of a website, where details of the scheduled classes, the events being organised and the providing of links to sister organisations under the Revolution BJJ banner. On the website they have also facilitated a mechanism for socialisation in a forum-type setting and this allows individuals with the organisation to interact and exchange ideas and opinions. The knowledge that exists within the organisation has benefited the team as a whole. It has provided their students with a competitive advantage which has led to success on both national and international level.

4.3.4 Extra-Organisational Level

At an extra-organisational level, there is knowledge which is critical to the success of Team Ryano. In order to put it fighters in competitions, the team has knowledge of the various promoters who run events. Their knowledge of these events and the promoters has been acquired not only from the relationships between other groups but also within the Irish, and International communities of practices. From their relationships, they have been able to obtain entry for fighters to participate in international events across the UK and Mainland Europe. Due to their standing in the MMA communities they have been asked to participate in attempts to create an Irish governing body in MMA. However due to the complications and the different philosophical outlooks from the various members, a fully-fledged governing body has not yet been realised.

4.3.5 Knowledge Management in Team Ryano

Whilst no conscious attempts have been made to introduce knowledge management into the organisation, we have seen that some of the principles are used informally. The core of the martial art learning in the club is performed in the form of the apprenticeship model (section 2.3.1) and is supplemented through socialisation (section 2.3.3) with the individuals of the various groups. The activity is also supplemented from internalisation of knowledge artefacts but this activity is not managed or controlled centrally by the organisation. On occasion various techniques performed in the club have been captured on video and uploaded onto the YouTube website. This has been performed more out of interest rather than to further organisational goals. The complexity of knowledge that exists within the sports as well as Team Ryano provides a useful vehicle to justify our research into the area. In our research, we will look at capturing tacit knowledge of an instructor using techniques which are used in knowledge management. Once captured explicitly, this knowledge can be represented and disseminated to individuals not only within the Team Ryano organisation, but also to the MMA community at large.

4.4 Conclusions

This chapter provided an overview of the sport of MMA. In section 4.2, we looked at the evolution of the sport from its historical roots through to the modern age. We looked at the various strategies that are fundamental to the sport. The Irish MMA scene was discussed and we illustrated how the growth of the sport has directly influenced the community which now exists. In section 4.3, we focused on the Team Ryano organisation and identified the how knowledge is used and created.

In order to put the thesis in context with the themes discussed in this chapter. The thesis is concerned with the elicitation of knowledge techniques from the field of mixed martial arts (section 4.2). These techniques are used in within the rules of the sport (section 4.2.3) and have been successfully employed in MMA strategies (section 4.2.4). The experiments will be conducted at Team Ryano in Baldoyle (section 4.3), members of the Irish MMA community (4.2.5). Our elicitation will focus on tacit knowledge that exists within the BJJ group and the MMA groups (section 4.3.2). This knowledge elicitation exercise will be performed using the head coach of the organisation, Andy Ryan (section 4.3.1.3), as our primary SME. The elicitation exercise aims to externalise this knowledge, this providing a valuable knowledge artefact.

5 EXPERIMENTAL DESIGN

"No design works unless it embodies ideas that are held common by the people for whom the object is intended."

Adrian Forty

5.1 Introduction

In the previous three chapters, we have established the context of the experiments being undertaken in this research. In chapter two, the role of knowledge and its importance in the field of knowledge management was discussed. In chapter three, the role of knowledge acquisition (KA) and the subset, knowledge elicitation (KE), which focuses on the elicitation of knowledge from human sources, was investigated. The previous chapter focused on the field of study in which the KE experiments will be performed, Mixed Martial Arts (MMA).

In this chapter, we will establish the research question that will be answered during the course of our experiments in section 5.2. In section 5.3, we will identify the goals of the research by looking the questions which were raised as a result of our research question. From our literary review, we will establish the requirements for our experiments in section 5.4. In section 5.5, we will examine the selections made during our design phase. We will conclude the section by establishing the previous work that had been done in the field and this was then related to our work (section 5.6).

5.2 Research Question

As seen in section 4.3, Team Ryano is an Irish MMA organisation where knowledge predominantly exists tacitly. We established that Team Ryano has no formal knowledge management (KM) structure in place. As a sports coaching organisation, the core service of Team Ryano is to teach students knowledge required for participation in the various martial arts that are taught. In analysing the acquisition of

knowledge in Team Ryano, we identified some informal channels in which knowledge is acquired (e.g. socialisation between its group members, internalisation of knowledge artefacts by individual). However for the most part, knowledge is acquired at an individual and group level through the use of the traditional apprenticeship model (detailed in section 2.3.1). In this model, students acquire techniques and strategies in the sport specific courses, through observing instructors demonstrations of tacit knowledge, the coaching phase and through practice.

Difficulties arise in the acquisition of this knowledge, when the student fails to pick up the various nuances required to accurately model the tacit knowledge of the instructor. The difference between a student's knowledge and that of the expert's level is known as the *"zone of proximal development"* (Vygotsky, 1978). The hypothesis for our research is that elicitation techniques from the field of knowledge management can help reduce this gap, by exposing the tacit knowledge of an expert.

5.3 Further Research Questions and Research Goals

As a consequence of the above research question, a number of additional questions can be investigated as part of this experiment.

The first question is how can tacit knowledge in the procedural steps, required to perform techniques in the field of MMA, be elicited? In this research, we will investigate the use of knowledge elicitation techniques in acquiring knowledge not normally explicitly articulated in training sessions.

In the developing the experimental methodology, questions will be addressed as to on how the experiments will be conducted. From the research in section 3.2.1, we made reference to the knowledge acquisition bottleneck significantly impacting the knowledge elicitation process. So how can these issues be eliminated or minimised the issues of the knowledge acquisition bottleneck? The research will focus on these at the issues in the course of experiments. In the selection of the appropriate knowledge elicitation techniques, more questions must be asked. Which methods are appropriate for this particulate research field? By performing an empirical investigation of KE techniques, it will be possible to identify the techniques which are effective and which ones are in efficient in the eliciting knowledge from an expert. We will also compare the type of knowledge and the level of knowledge gained by each technique. Can these techniques be applied to different types of martial arts techniques? The experiments will aim to investigate how appropriate a single methodology is in the elicitation of tacit knowledge pertaining to different martial arts techniques.

5.4 Establishing Requirements

In the literature review of knowledge elicitation techniques, detailed in section 3.3.3, we established the pre-requisite requirements for performing knowledge elicitation. The first requirement was to identify valuable knowledge. In terms of the martial arts field, it is necessary to identify the techniques and the strategies that are of importance. In order to be of benefit to the Team Ryano organisation, another key issue in the experimental design is that the selected techniques are not only important in the field of MMA but they have relevance in other related fields, such as BJJ and Judo, which are also taught within the organisation. The next requirement in the experiments is to ensure that the totality of knowledge being externalised is representative of the knowledge that is used at Team Ryano. In this task, it is important to select the relevant knowledge sources that exist in the organisation. Where possible it is more suitable to use multiple sources of expertise in acquiring the knowledge, as this reduces the bias inherent from a single knowledge source. The selection of an appropriate knowledge engineer is critical for the success of the knowledge elicitation session. In these experiments, the engineer will be responsible for implementing the selected methodology. In section 3.3.3, we identified the soft skills and the technical skills required in knowledge elicitation. Table 5.1 contains the summarised skill set identified in the literature review.

Soft Skills	Technical Skills
Self-Confidence	Working knowledge about the domain (e.g.
	Concepts And Terms)
Tact And Diplomacy	Awareness of recent developments
Intelligence	Ability to be critical of the knowledge
	transferred
Versatility	Aware of the most appropriate KE techniques
Inventiveness	
Empathy	
Patience	
Persistence	

Table 5.1 Skills of Knowledge Engineer

For these experiments to proceed as planned, participation in the experiments must be encouraged as well as provisions made for an environment and the essential materials where these experiments can be conducted. The focus of the research centres on the selection of appropriate knowledge elicitation techniques which need to be applied to the area of knowledge in which our experiments are focused. To manage the knowledge elicitation process, we must ensure that the experiments are clearly focused on the goals of the research.

5.5 Design Selection

Based on the requirements, the following section details the selection process which has been performed.

5.5.1 Identifying Valuable knowledge

For the purpose of this research, the focus will be on to two techniques that not only have been used successfully in MMA competition but their roots lie in different disciplines.

The Tai-otoshi Throw

The first technique is a throw in Judo known as *Tai-otoshi*. A throw is used to take the opponent down to the ground. The *Tai-otoshi* is a technique that can be employed by all weight categories. Typically throws that are performed by smaller practitioners, to utilise speed and a low centre of gravity to perform the technique whilst larger practitioners use throws that that require upper body control to pull a lighter opponent over. This technique does not require either to be successfully employed. It simply uses the forward momentum of the opponent to take them to the ground. The throw is highly versatile in that it can be performed direct attack or can be employed in combination with other throws as part of a strategy to take an opponent to the ground. Whilst more extensively used in Judo and BJJ, it has been successfully employed in MMA.



Figure 5.1 Tai-otoshi Throw

The Arm-Bar

The second technique which will be examined for the purposes of our experiments is the arm-bar. In Judo, this technique is known as juji-gatame. This technique aims to hyperextend the elbow joint which can result in muscle, tendon and ligament damage, even dislocation, or bone fractures, if the opponent does not submit at the point of application. This technique is perhaps the most versatile of all the submission techniques and can be employed in numerous ways.



Figure 5.2 Arm-bar Submission

By focusing on these two significantly different techniques, we aim to determine how suitable KE techniques are for the elicitation of knowledge in the context of mixed martial arts but also other fields of Martial Arts.

5.5.2 Identifying Relevant Knowledge Sources

For the purposes of the experiments, it is important to select a knowledge source from which knowledge of these techniques exist. Due to the difficulties associated with the availability of multiple experts in the field, for the purposes of our experiments, a single source will be used. In selecting in an expert for the study, it was essential that the expert selected has the two characteristics identified previously for an expert coach i.e. playing experience and teaching experience (Schempp, 2000). Andy Ryan, the head coach of Team Ryano, agreed to at as the subject matter expert (SME) in the experiments. Whilst the use of a single source has been identified as risk for bias, Andy's extensive knowledge of the Judo, BJJ and MMA provides a rich source of knowledge. To negate work pressures, the experiments will be performed before, after and during group practice. In using the head coach of Team Ryano, who has over thirty years experience in the field, we believe that we can fully encapsulate the knowledge contained in the two techniques.

5.5.3 Selection of the Knowledge Engineer

The experiments will be conducted by the author. He has been a member of Team Ryano since 2005 therefore it is expected that he has an existing relationship with the subject matter expert that eliminates the risks involved with partial or non-participation. He has pre-requisite knowledge of mixed martial arts, BJJ and Judo. Although this might serve as a potential source of bias, care will be taken not to influence the domain expert in the KE sessions and the engineer will remain as impartial in the sessions as possible and focus on the goals to the elicitation process.

In terms of the knowledge elicitation processes, the knowledge engineer will be responsible for the creation and the execution of the experiments. In terms of the knowledge elicitation experiments, the engineer will be responsible for recording, taking notes and answering the expert's questions in terms of the knowledge elicitation process whilst the sessions are being conducted. Once performed, the knowledge engineer will be responsible for the analysis of the sessions. It is his findings that will form the basis of our results.

5.5.4 Material Requirements

From the purpose of the experiments, the facilities available at Team Ryano in Baldoyle will be used. The data capture will be performed using a video camera; computer-based recording tools; and video editing software. The analysis of the sessions will be conducted manually using video analysis software and word processing software to capture the results.

5.5.5 Terminology List

The first task which will be undertaken is to create a list of technical terms and their respective definitions used in the field of mixed martial arts. This will serve as an aid for the knowledge elicitation process in which the knowledge engineer can fully understand the abstractions of concepts being exposed by the subject matter expert and

provide a common language in which the knowledge engineer can gain deeper understanding of the concepts being considered.

In constructing the list, the knowledge engineer will initial create a list from various sources available online. Online sources will be used as a means of populating the list an attempt to omit bias from the experiments, making them repeatable by knowledge engineers who have limited or no knowledge in the problem domain. During the elicitation process, it is expected that additional terms and definitions will be added to the list and some definitions revised. This will be performed with the assistance of the subject matter expert.

5.5.6 Initial Demonstrations Of Knowledge

In order to evaluate the knowledge elicited during the knowledge elicitation sessions, the SME will be asked to conduct an initial demonstration of the techniques which will be the focus of the knowledge elicitation sessions. These will be recorded by the knowledge engineer with help from various members of the Team Ryano, who will be used in the demonstration. The demonstrations will focus on the knowledge typically delivered during a demonstration of knowledge in the observation phase performed during classes. This will serve as the benchmark for which the generated protocols of the knowledge elicitation sessions will be compared against.

5.5.7 Selection of Knowledge Elicitation Techniques

In selecting these techniques for the knowledge elicitation sessions, there are various considerations. Stated in the goals section, we aim to elicit knowledge of techniques in MMA. From our literature survey of knowledge elicitation, techniques will be employed that have been seen to elicit procedural knowledge required. The use of tools that have been seen to identify goals and sub-goals have been omitted from our selection process as stated in section 3.3.4.3, these techniques do not respect the order in which steps are performed. Whilst these techniques might provide additional knowledge, they could impact the time taken to analyse the task, thus increasing

latency associated with the knowledge acquisition bottleneck. Strategic knowledge with respect to the various environmental variables should also be identified as this will help us understand the decision making processes and conditions required in order to successfully perform these techniques can be performed (section 3.3.4.4). Other considerations when selecting the techniques is that the elicitation of knowledge is from a single expert in the field. This will eliminate techniques indentified in section 3.3.4.3.

The selection process is further complicated due to the physical nature of the knowledge being demonstrated. Techniques such as card sorting and repository grids are more difficult to implement given the constraints of the field. In order to address the omission of these techniques, techniques that span multiple categorisations will be employed i.e. techniques that are considered direct or indirect methods (section 3.3.4.1) and are either natural or contrived techniques (section 3.3.4.2).

In the following section, we will look at the individual techniques that will be selected as part of the knowledge elicitation process, detailing the processes involved as well as identifying the various categorisations in which they are considered to be part of, as discussed in section 3.3.4.

5.5.7.10utput - Input - Middle Interview

A semi-structured interview technique, which *Becerra-Fernandez et al.* (2004) employ in eliciting knowledge from an expert is entitled the *Output-Input-Middle* interview. In performing this task, the Knowledge Engineer asks the SME to establish the goals of the knowledge under discussion (i.e. outputs). In this step, the identification of the various goals and differences between each one is established. Once these are established, the SME will identify the various environmental variables which they use in order to deduce the solution (i.e. inputs). The knowledge engineer is responsible for making explicit how these inputs are indentified. The final step (i.e. the middle) is the used to determine the links between the inputs and the outputs. These connections represent the core of the SME's knowledge in which goals and intermediate steps will be identified to complete the link. This step is useful in that it can also identify environmental inputs which were not identified in the first step.

In terms of the categorisations detailed in section 3.3.4, semi-interviews are considered to be a direct technique in which knowledge can be elicited directly from the SME during the course of a KE session. They also benefit from being a natural technique in which the SME will be comfortable with as the technique would not be too dissimilar from the task of explaining their techniques in a classroom situation. From the perspective of different knowledge types in section 3.3.4.4, the interview technique has been seen to elicit procedural and strategic knowledge.

For the purposes of the experiments a modified version will be used which will allow the expert to perform a physical demonstration of each step to illustrate the output, input and middle elements of their knowledge. From this technique, we aim to elicit procedural knowledge of the steps required to perform the techniques, strategic knowledge in terms of the environmental conditions in which the technique can be performed and goal knowledge in terms of the purpose for the utilisation of the technique.

5.5.7.2 Commentary

Commentary is another KE technique which elicits knowledge from an expert by having the expert provides a running commentary on a typical task used in the problem domain. The commentary protocol can be employed in one of two different ways (Hannu and Pallab, 2000), either concurrently (i.e. providing commentary whilst the task is being performed) or retrospectively (i.e. after the task has been performed). In the retrospective approach, an expert is shown a protocol of task behaviour, and asked to provide commentary on the thinking processes in performance of the task. This can occur in one of two ways, either through self-reporting or as means of critiquing the performance of others. An advantage of the retrospective approach is that video can be paused or run at slow speed to allow time for the SME to provide full explanation of the decision making processes involved. This is particularly useful in dynamic domains (Hannu and Pallab, 2000).

In terms of the categorisations detailed in section 3.3.4, commentaries are considered to be a direct technique. They differ from interviews in that they are considered a contrived technique in which the SME i.e. a task which is not normally performed during their everyday tasks. From the perspective of different knowledge types in section 3.3.4.4, the commentary technique has been seen to elicit strategic knowledge as well as providing a source of evaluation. However the use of commentary in our experiments will not be used as a method for evaluation, instead we will aim to elicit strategic knowledge only.

In the experiments, the retrospective version will be used, where the expert will be presented with a series of videos of the associated techniques being performed in a competition. The expert will then be asked to provide a commentary, critiquing the techniques of others as they perform. To minimise the impact of the knowledge acquisition bottleneck, demonstrations of technique will not recorded by the knowledge engineer but randomly selected from examples of the techniques being elicited, freely available on the Internet. This also serves as a means of making the experiment repeatable.

5.5.7.3 Triadic Elicitation with use of Video Technology

Triadic elicitation is knowledge elicitation method used to capture the way in which an expert views the concepts in a domain. Traditionally, a knowledge engineer populates an experimental set with concepts from the domain under consideration during the knowledge elicitation session. The knowledge engineer will than present three random concepts within the set to SME. Upon presentation of these concepts, the SME will be asked to select two of the three that are the most similar. Once identified, the Knowledge Engineer will then ask the SME to give a reason as to why the third was different. This differentiating factor will identify a characteristic of the overall set of concepts being considered.

From the standpoint of our categorisations (section 3.3.4), triadic elicitation is a direct technique (section 3.3.4.1), and considered to be contrived technique (section 3.3.4.2).

This type of technique aims to elicit knowledge found in classifications and dependencies and relationships (section 3.3.4.4).

In this research a modified version of this technique will be presented in which concepts from the field will be replaced by video variations of the MMA technique being performed in competition. As with the commentary technique detailed in section 5.4.5.2, we will randomly select videos found online, thus making the experiment repeatable as well as to minimise the effect of the knowledge acquisition bottleneck. Although the traditional method of triadic elicitation does not elicit procedural knowledge, it will be of interest to see how the modified version will perform. In using this technique, we hope to expose different types of knowledge to the other techniques used in the KE sessions.

5.5.7.4Cognitive Walk-Through (Think Aloud)

Similar to the commentary method used illustrated in section 5.5.7.2, the *Cognitive Walk-Through* (also known as the *Think Aloud* method) is KE technique in which an expert articulates their knowledge concurrently whilst working through a problem or a task (Wright & Ayton, 1987). The method enables knowledge engineers to observe the thought processes of the expert during the performance of the task. This is a powerful technique in the identification of knowledge elements and steps. According to Ericsson and Simon (1980,1984), the concurrent verbalisation element provides a complete report of the knowledge being demonstrated as no thought, feeling, or action is omitted from their account. In tasks where significant cognitive effort is required, this method may interfere with the expert's performance. As a means of negating this limitation, a retrospective variant can be employed in which the expert provides a commentary of their thought processes whilst observing themselves performing the task. However this variant does not provide the knowledge engineer direct access to the decision making process as it happens.

In terms of the categorisations detailed in section 3.3.4, the cognitive walk-though is considered to be a direct technique in which knowledge can be elicited directly from the SME during the course of a KE session. They differ from interviews in that they

are considered a contrived technique in which the SME i.e. a task which is not normally performed during their everyday tasks. From the perspective of different knowledge types in section 3.3.4.4, the cognitive walkthrough technique has been seen to elicit procedural and strategic knowledge. For the purpose of this research, the concurrent version of the technique will be employed. In this we aim to elicit knowledge of the individual steps required in performing the task.

5.5.7.5 Teach Back

Another technique which will be used in the elicitation of knowledge from our domain expert is the use of *Teach Back*. In this technique, the knowledge engineer will act as the expert (or more correctly a pseudo-expert) and will attempt to solve the problem in the presence of the SME. The knowledge engineer will present their own understanding of recently acquired knowledge to the expert. The expert will then critique the knowledge and provide feedback to the knowledge engineer until the expert is content that the knowledge of the knowledge engineer accurately maps their own. This technique is typically used when the knowledge engineer to verify their correct understanding and can be used to clarify, modify and provide new knowledge not previously elicited from the previous knowledge elicitation techniques (*Becerra-Fernandez et al.*, 2004). However it is warned that the technique is limited to the knowledge being demonstrated by knowledge engineer and does not provide any additional knowledge outside of the scope of the teach back activity (van der Veer, G. C. & del Carmen Puerta Melguizo, M., 2002).

In terms of the categorisations detailed in section 3.3.4, Teach Back is considered to be a direct technique in which knowledge can be elicited directly from the SME during the course of a KE session. Although this technique is considered contrived, our expert regularly performs this task in his role coaching activities. From the perspective of different knowledge types in section 3.3.4.4, the Teach Back technique has been seen to elicit procedural knowledge and evaluation knowledge. In our experiments, the knowledge engineer will be recorded demonstrating the knowledge of the techniques provided by our expert, from this we aim to get validation from the expert that the elicited knowledge of the individual steps required in performing the task, matches his mental model.

5.5.8 Analysis of Knowledge Capture

Once the knowledge elicitation sessions are completed, the next step will be to analyse the produced protocol from our knowledge elicitation sessions. Each of the techniques will require different types of analysis.

5.5.8.1Analysis of Initial Demonstrations

In analysing the initial demonstrations, the first step will be to identify the verbal articulations. This will be performed in the form of a transcript which will be produced from the resulting protocols. In producing this transcript, it is envisaged that further terms and concepts will be identified from the KE process. These terms will be clarified with the subject matter expert and added to the existing list of terms. The second step in will be to analyse the non-verbal articulations. In this we will attempt to represent the movements used by expert and his partner in his demonstration of technique. Once the first two steps have been performed, the two articulations will be merged. In this we hope to identify the intersections and from this produce a model of the knowledge being demonstrated. We will then categorise the knowledge which has been elicited from the experiments into respective groupings.

5.5.8.2Analysis of Output - Input - Middle Interview Demonstration

In analysing the Output-Input-Middle Demonstrations, as in the initial interview, we will transcribe the verbal articulations from the generated protocol from our data capture session. The terminology list will be updated with terms and their associated definitions as and when they occur. Once again the non-verbal articulations will be

examined and movements articulated. The two artefacts will be merged to order to bring meaning and context to the two artefacts. We will then categorise the knowledge which has been elicited from the experiments into respective groupings.

5.5.8.3Analysis of Commentaries

In analysing the Commentaries, as in the initial interview, we will transcribe the verbal articulations from the generated protocol from our data capture session. The terminology list will be updated with terms and their associated definitions as and when they occur. Once again the non-verbal articulations will be examined and movements articulated. The two artefacts will be merged to order to bring meaning and context to the two artefacts. We will then categorise the knowledge which has been elicited from the experiments into respective groupings.

5.5.8.4Analysis of Triadic Elicitation

In analysing the Triadic Elicitation, as in the initial interview, we will transcribe the verbal articulations from the generated protocol from our data capture session. The terminology list will be updated with terms and their associated definitions as and when they occur. From this we will create a mapping of the differential operators and create a diagram in how they relate to each other. From this we will then be able to analyse the knowledge in terms of the categorisations of knowledge which we made reference to section 3.3.4.4.

5.5.8.5Analysis of Cognitive Walk Through And Teach Back

In analysing the Cognitive Walk Through and the Teach Back methods will be essentially the same as the initial interview, we will transcribe the verbal articulations from the generated protocol from our data capture session. The terminology list will be updated with terms and their associated definitions as and when they occur. Once again the non-verbal articulations will be examined and movements articulated. The two artefacts will be merged to order to bring meaning and context to the two artefacts.

5.5.9 Comparison of Techniques

Once the individual knowledge artefacts have been analysed the next step will be to compare the different techniques against other. In this we can make interesting comparisons between the KE elicitation techniques as well as the initial demonstration of technique. We will look at the requirements and issues required the various experiments (e.g. time taken to set up the experiments, the role of the SME, the role of the KE, the quality of the generated protocols, the intersections of where knowledge accurately maps). Finally we will compare the findings from the two techniques in order to see if the methodology was more appropriate for the *tai-otoshi* or the arm-bar.

5.6 Related Work

The field selected for this research is a relatively new field of endeavour. Very little research exists in terms of a eliciting knowledge from motor skills. However, one such work is research being conducted in the field of acquiring craft skills (Wood, 2004). The research is centred on the use of knowledge elicitation techniques in the learning of craft skills in the creation of a simple low-tech video resource to assist acquiring knowledge in the field. Wood suggests that craft practitioners do not have the teaching experience and are unable to express the knowledge they possess i.e. most of a practitioners skills are tacit. The goal of the elicitation was not obtain a list of steps in the process but to acquire rules of thumb that would assist the student's knowledge acquisition. As with our research, the experiments were performed using a single subject matter expert. In selecting their expert, Wood simply makes reference to a craft practitioner; in our research we shall be using an individual who is an expert practitioner as well as an expert teacher in the field. While five different methods, will be used our knowledge elicitation sessions, only two were used in theirs, commentary and cognitive walkthrough. In commentary, the expert was recorded performing the task. The video was then shown to the expert and then the expert was asked to critique the performance. This critique was then recorded for later analysis. This differs from the commentary being used in our work; ours will focus on the critiquing of the performance of other practitioners. The next technique used was the cognitive walkthrough in which the practitioner was recorded and asked to talk through their work as they performed it. The video was then analysed by the expert and the knowledge engineer in order to gain additional findings. In our version of the experiments, the analysis of the cognitive walkthrough video will not be performed. From the findings, it is suggested that the commentary provided the best results as they stimulated more in-depth discussion.

5.7 Conclusions

This chapter established the research question that we will answer during the course of our experiments in section 5.2. In section 5.3, we identified the goals of the research by looking the questions which were raised as a result of our research question. From our literary review, we established the requirements for our experiments in section 5.4. In section 5.5, we looked at the selections made during our design phase. We concluded the section by defining the methodology selected for the KE process. Finally we established the previous work that had been done in the field and this was then related to our work (section 5.6).

In order to put the thesis in context with the themes discussed in this chapter. The thesis is concerned with the elicitation of knowledge from a SME in the field of MMA. In eliciting knowledge required in the performance of MMA techniques, a systematic methodology has been developed (section 5.5) based on specific design requirements (section 5.4) in order to address the questions raised by the author (sections 5.2 and section 5.3). The experiments will use five KE techniques, Output - Input - Middle Interview (section 5.5.7.1), Commentary (section 5.5.7.2), Triadic Elicitation (section 5.5.7.3), Cognitive Walkthrough (section 5.5.7.4), and Teach Back (section 5.5.7.5) in order to elicit knowledge from the SME. The output of these techniques will be analysed (section 5.5.8) and compared against the SME's initial demonstration of technique.

6 EXPERIMENTATION AND EVALUATION

"Sometimes it takes an expert to point out the obvious."

Scott Allen

6.1 Introduction

Based on the design presented in chapter 5, the following chapter will map the experiment process. Section 6.2 we will look at the implementation of the experimental design. Once the findings have been established, lessons learnt from the experiments will be presented in the form of a critical review of the experimental process in section 6.3. The chapter will be concluded with an overall critical review of the process in its entirety in section 6.4.

6.2 Experiments

In this section, the steps which were performed during the course of the experiments will be detailed. In section 6.2.1, the initial steps taken in the preparation for the experiments will be established. The creation of the initial dictionary of terms, which will aid the knowledge engineer during the analysis phase, will be detailed in section 6.2.2. A detailed account of process required to capture the initial demonstrations will documented in section 6.2.3. In section 6.2.4, the capture phase of the knowledge elicitation experiments will be discussed. Once captured, the steps taken to analyse the captured sessions will be discussed in section 6.2.5. The chapter will conclude with a comparison of the knowledge elicitation essions with reference to the initial demonstration of technique in section 6.2.6.

6.2.1 Preparation of the experiments

In preparation for these knowledge elicitation experiments, the knowledge engineer requested the assistance of the subject matter expert (SME) in participation for the

experiment. The knowledge engineer's personal relationship to the SME helped negate some of the issues normally associated with SME involvement in knowledge elicitation (KE) exercises (identified in section 3.3.2.1) such as fears associated with loss of knowledge, work demands and finding time for knowledge elicitation sessions.

Before commencing the knowledge elicitation exercises, the SME was given an overview of the experiments and the aims of this research. He was also made aware of his role in the knowledge elicitation exercise in which he was happy to participate in. For the purposes of these experiments, Andy gave us permission to use the facilities at the Team Ryano gym in Baldoyle. This was very helpful as it allowed the experiments to be performed safely in an appropriate space, and created a comfortable environment for both the SME and his demonstrators which they were already familiar with, and were thus uninhibited in terms the physical demonstrations.

The experiments were conducted over a period of four months between November 2009 and March 2010. The knowledge elicitation exercises were conducted in and around class sessions, in order to reduce work pressures, the SME might have had.

Additional material equipment was required for the experiments. In terms of knowledge capture, two video cameras were used in the production as well as video editing software (Microsoft Movie Maker) and file format conversion software (Magic Video Converter). Access to online video resources was required for various knowledge elicitation experiments conducted as part of the experiments.

6.2.2 Creation of the List of Terms

The first task that was conducted was the creation of terminology list. In the creation of the initial list of terms, we used three online sources were selected. The first source was the Warrior Pages MMA terminology list (Warrior Pages, 2010). This provided a general list of terms and definitions. This source generated 10 terms and definitions. The second source, for the terminology list was another general source of terms which was the Ground and Pound MMA terminology list (Ground and Pound, 2010). This source was used to supplement to Warriors Pages MMA list. This source generated

101 terms and definitions. The third source was acquired from the Elite MMA referee school (Elite MMA, 2010). In extracting these terms, it was hoped that this would enrich the list of terms and definitions from the perspective of MMA referees and MMA officials who work within the sport. This source provided 28 terms and definitions. The terms were then analysed and a syntactic category was attached to the terms from this 3 verbs, 1 name, 1 acronym and 133 nouns were identified.

6.2.3 Initial demonstration of the martial arts technique

The first task in the elicitation process was the initial demonstration. The knowledge engineer asked the SME to conduct demonstrations of the *Tai-otoshi* and Arm-bar techniques (identified as the two techniques to be elicited for the purpose of the experiments in section 5.5.1) as they would be typically performed in class-based situations. In this demonstration, the structure of the demonstration was the responsibility of the SME, the only considerations given was that his performance should include strategic and procedural knowledge of how the techniques should be performed. For both techniques, the initial demonstration was recorded using a single video camera and the recording performed by the knowledge engineer. In the demonstration of the *tai-otoshi*, the camera was fixed in one point whilst in the demonstration of the arm-bar; the knowledge engineer followed the demonstration.

The arm-bar demonstration started with three non-verbal demonstrations of strategic and procedural knowledge in applying the arm-bar; from the knee-ride position, from the mount position and from the guard position. In the next phase of the demonstration, the application of the arm-bar was introduced (figure 6.1). The demonstration started from a seated position and the SME, verbally and non-verbally, illustrated the application of the technique.



Figure 6.1 Arm-bar Initial Demonstration

The *tai-otoshi* demonstration started with a non-verbal demonstration of the technique. The SME demonstrated two variants of the *tai-otoshi* throw (figure 6.2). One in which the throw was performed with the attackers hand on the back of the gi and the other was performed with the hands on the same side of the gi. Both of these demonstrations were verbally and non-verbally explained by the SME. The demonstration was concluded with variations of both techniques.



Figure 6.2 Tai-Otoshi Initial Demonstration

Once each of the demonstrations had been performed, the SME was asked to review the demonstrations. Once agreement had been reached, the knowledge engineer then took the file and converted it for use with the video editing software. The video was then produced and formed the basis for the analysis which was performed in section (6.2.5.1).

From the initial demonstration of knowledge, in the demonstration of the arm-bar, the SME introduced the new term (a noun) and used none of the existing terms defined in the terminology list. In the second demonstration of *tai-otoshi*, no terms were introduced, as the SME used common language in explaining the techniques. Once again none of the terms found in the extracted terminology list were used.

The performance of the arm-bar experiment is available on the accompanying DVD in the /Armbar/InitialDemo/ folder in the file entitled InitialDemo-Armbar.avi. The performance of the *tai-otoshi* is available on the accompanying DVD in the /Tai-Otoshi/InitialDemo/ folder in the file entitled InitialDemo-Tai-Otoshi.avi.

6.2.4 Knowledge Elicitation Experiments

Once the initial demonstrations of technique had been performed for both techniques, the knowledge elicitation experiments were conducted. With the awareness of the stress induced by the videoing process, the knowledge engineer avoided creating additional stress for the SME by interrupting and requesting clarifications (e.g. terms, goals-sub goals, *etc.*). Clarifications were requested after the demonstrations.

6.2.4.1 Output - Input - Middle Demonstration

The first elicitation session conducted using the output-input-middle (OIM) demonstration. As stated in the experimental design section, the SME was asked to identify the outputs (the goal or goals of successful completion of the technique) and the inputs (the environmental conditions which allow this technique to be performed) before the technique was demonstrated. The knowledge engineer asked how the SME would like to articulate the middle section of the demonstration (i.e. the tasks involved

performing the technique). The SME's preference was to talk through the demonstration as it was being performed. Both of these techniques were recorded in one take.

In the OIM for the arm-bar, the SME performed the technique twice, once from the knee-ride position and once from the mount (figure 6.3). The SME verbally identified the starting point of both (i.e. knee ride and mount) and the end of goal of submission. The steps involved for completing the arm-bar were slightly different from that his previous demonstration of technique in the knee ride position. This demonstration contained mainly non-verbal articulation.



Figure 6.3 Output Input Middle Arm-Bar Demonstration

In the OIM for the *Tai-otoshi*, the SME performed the technique once (figure 6.4). The SME verbally did not identify the starting point. The knowledge engineer did not correct the SME at this point, as it was more important to establish a rapport and create a relaxed environment to facilitate sharing. However the goal of the throw was established, which was to take the opponent to the ground and for a submission to be applied. The steps involved in completing the *tai-otoshi* were articulated verbally and non-verbally.



Figure 6.4 Output Input Middle Tai-otoshi Demonstration

In performing these experiments, the demonstrations contained mainly non-verbal articulations. From the output-input-middle demonstrations, the SME introduced four new terms (2 verbs and 2 nouns) and used one new term (mount) defined in the terminology list.

As with the initial demonstration of technique, the knowledge engineer was responsible for taking the file and converting it and editing for the analysis which performed in section 6.2.5.2. The performance of the arm-bar experiment is available on the accompanying DVD in the /Armbar/OIM/ folder in the file entitled OIM-Armbar.avi. The performance of the *tai-otoshi* is available on the accompanying DVD in the /Tai-Otoshi/OIM/ folder in the file entitled OIM-Tai-Otoshi.avi.

6.2.4.2 Commentary

The next experiment was the commentary elicitation technique. For the purposes of the experiments, the knowledge engineer was responsible for setting up the experiment. The videos used in the commentary process were randomly selected from examples of the two techniques being performed as part of the elicitation process, from online sites such as YouTube and DailyMotion. Once found, the knowledge engineer downloaded them for use by the SME. The videos were edited to show only the
preceding actions which were performed before the technique was employed. The demonstrations were played twice on a loop. The first time providing a demonstration played in real-time and the second providing a demonstration played at half speed.

For each technique, the SME was shown five variations of each technique and asked to critique the performance (figure 6.5). In performing this, the SME was highly articulate and generated more verbal articulations than had been seen in the previous experiments.

From the commentary demonstrations, the subject matter SME introduced three new terms (2 nouns and 1 verb) and used one that was generated in the output-input-method. The SME also used three terms that existed in the generated list of terms.



Figure 6.5 Clip from the Arm-Bar Commentary Technique

In order to record the SME during the elicitation section, the knowledge engineer used CamStudio software, which allowed the SME's verbal articulations to be recorded whilst observing the videos. The generated file was taken, converted and edited for the analysis which performed in section 6.2.5.3. The performance of the arm-bar experiment is available on the accompanying DVD in the /Armbar/Commentary/ folder in the file entitled Commentary-Armbar.avi. The performance of the *tai-otoshi* is also available in the /Tai-Otoshi/Commentary/ folder in the file entitled Commentary-Tai-Otoshi.avi.

6.2.4.3 Triadic Elicitation with use of Video Technology

The next experiment was the triadic elicitation using video technique. As with the commentary experiment, the knowledge engineer was responsible for setting up the experiment. The videos used in the triadic elicitation process were randomly selected from examples of the two techniques being performed as part of the elicitation process, from online sites such as youtube and dailymotion. The five videos used in the commentary process were included in the set used for the experiments, reducing the take taken to perform the task. At total of twelve videos, were used in the process. At total of ten experiments were performed. They were shown using a program called cSwing by Sports Motion. This allows videos to be displayed on the same screen at the same time. It also allows slow down the action, so that the SME could fully observe the techniques being performed.



Figure 6.6 Clip from the Arm-Bar Triadic Elicitation Technique

In this technique, the knowledge engineer presented three random clips of the arm-bar and the tai-otshi techniques being performed to SME (figure 6.6). Upon presentation of these clips, the SME was asked to select two clips which were the most similar and asked what differentiated these from the third. The method succeeded in generating verbal articulations from the SME. From the experiment, 5 new terms were generated (5 nouns) and used two that were generated previously in the experiments. The SME also used five terms that existed in the generated list of terms.

As with the commentary experiment, the knowledge engineer used the CamStudio software to record the SME's verbal articulations whilst observing the videos. The generated file was taken, converted and edited for the analysis which performed in section 6.2.5.4. The performance of the arm-bar experiment is available on the accompanying DVD in the /Armbar/TE/ folder in the file entitled TE-Armbar.avi. The performance of the tai- is also available in the /Tai-Otoshi/TE/ folder in the file entitled TE-Tai-Otoshi.avi.

6.2.4.4Cognitive Walkthrough

The next elicitation session conducted using the cognitive walkthrough. As stated in the experimental design section, the knowledge engineer asked the SME to articulate their knowledge concurrently whilst working through the techniques. Both of these techniques were recorded in one take.

In the arm-bar demonstration, the demonstration started at the same point the SME started his verbal articulation in the initial demonstration (figure 6.7). In this demonstration, the SME was highly articulate. Although no new terms were introduced, the SME did use a term previously generated in earlier demonstrations but used none from the initial term list.



Figure 6.7 Arm-Bar Cognitive Walk-Through Technique

In the *tai-otoshi* demonstration, the demonstration started at the same point the SME started his verbal articulation in the initial demonstration (Figure 6.8). In this demonstration the camera was located in a fixed point and the SME moved around as that all aspects of the throw were seen by the camera. In these demonstrations, the SME generated less verbal articulations as a result no new terms were introduced or used in this demonstration.



Figure 6.8 Tai-otoshi Cognitive Walk-Through Technique

As with the initial demonstration of technique, the knowledge engineer was responsible for taking the file and converting it and editing for the analysis which performed in section 6.2.5.5. The performance of the arm-bar experiment is available

on the accompanying DVD in the /Armbar/CW/ folder in the file entitled CW-Armbar.avi. The performance of the *tai-otoshi* is also available in the /Tai-Otoshi/CW/ folder in the file entitled CW-Tai-Otoshi.avi.

6.2.4.5 Teach-Back

After the experimental design, it was decided that the teach-back technique was to be removed from the experiment set. It was felt that as the knowledge engineer already had experience in performing both techniques, the experiments would have been compromised in that the knowledge demonstrated by the knowledge engineer would have not necessarily been elicited during the experiments.

6.2.5 Analysis Generated Protocol

Once all the knowledge elicitation sessions had been captured, the next step was to perform the analysis of the captured knowledge elicitation sessions. For the purposes of the experiments, we were only concerned with two types of knowledge, the procedural steps required to perform the two techniques and the strategic knowledge when these techniques should be performed.

6.2.5.1Analysis of Initial demonstration

The first step in the process was to create transcripts of demonstrations (see appendix D). The non-verbal articulations were then added for both (an example is available in appendix E). As expected from the literature review the task of creating a transcript and in particularly the non-verbal analysis is a time consuming activity (Forsyth, 1993). The analysis was then performed, in this we focused on eliciting knowledge that was solely focused on the procedural steps and the strategic knowledge required to perform the technique. During the analysis process, the knowledge engineer kept notes on the analysis process from his analysis of the process. The terminology constructed

in the interactions with the SME assisted the knowledge engineer in the process. From this, the following insights were gained:-

Arm-bar Demonstration

In terms of strategic knowledge, the first demonstration non-verbally identified three positions in which the arm-bar could be applied. The positions were identified by the knowledge engineer as the knee ride position (figure 6.9), the guard position (figure 6.10) and the mount position (figure 6.11).



Figure 6.9 Knee Ride Position



Figure 6.10 Guard Position



Figure 6.11 Mount position

The next step in the initial demonstration was the verbal articulation of the arm-bar. From the observations we were able to identify a set of procedural steps, we constructed a set of steps which were performed (figure 6.12). Out of the nine steps, identified six were articulated verbally and three were articulated non-verbally.



Figure 6.12 Initial Demonstration Arm-bar Steps

In this diagram, the dark boxes denote all the steps that were articulated verbally and the light boxes denote the steps that were articulated non-verbally or partially.

Tai-otoshi Demonstration

The demonstration demonstrated two variants of the *tai-otoshi* throw, the *traditional* version. One in which the throw was performed with the attackers hand on the back of the gi whilst the other was performed with the hands on the same side of the gi. The strategic knowledge in which these two techniques could be performed was not established. In figure 6.13, we identified five steps required in performing the

technique, three of which were partially articulated verbally and the other two were articulated non-verbally.



Figure 6.13 Initial Demonstration Tai Otoshi Traditional Steps

In the demonstration of the second technique the *non-tradition* (figure 6.14), we identified seven steps required in performing the technique, four of which were partially articulated verbally and the other three were articulated non-verbally.



Figure 6.14 Initial Demonstration Tai Otoshi Non-Traditional Variation Steps

6.2.5.2 Analysis of the Output - Input - Middle Interview Demonstration

The analysis started with the creation of transcripts (Appendix D) and the addition of non-verbal articulations for both the *tai-otoshi* and the arm-bar (example in Appendix E). As the length of the experiments was significantly less than the initial demonstrations, this took significantly less time. The notes kept by the knowledge engineer during the analysis of the process. From the knowledge engineers analysis, the following insights were gained:-

Arm-bar

In comparison to the initial demonstrations of the technique, the SME verbally identified the starting point of the knee-ride and the mount position (two of the three positions non-verbally demonstrated in the initial demonstration) as well as the end goal, the submission (which was not formally demonstrated. These were only non-verbally demonstrated in the initial demonstrations of technique.

In the mount demonstration, additional steps were articulated demonstrating the steps involved in moving from the mount position to the seated position. From this position, the steps involved were similar to the initial demonstration, fewer steps were required in its application as there was the arms were already in the correct position and the SME did not require to establish balance before its application.

In the demonstration of techniques from the knee ride position, once again the initial steps involved in moving from the knee ride position were verbally identified. However the actual steps, involved in completing the arm-bar, were slightly different from the arm-bar demonstrated from the mount position. In this, one of the legs was positioned on the inside of the opponent's chest (figure 6.15). Despite this variation, the principle steps in the application of the arm-bar remained the same.



Figure 6.15 Variation of the Arm-bar from the knee ride variation

Tai-otoshi

In the *tai-otoshi* demonstration, the SME performed a single demonstration of the nontraditional version of the *tai-otoshi* demonstrated in the initial demonstration of technique. The output conditions of the technique were established, in that the aim of the techniques was to take the opponent to the ground. The input conditions for the when the throw could be performed were accidently omitted from the experiment. As the demonstration was performed very quickly, there was little articulation of the steps involved.

6.2.5.3 Commentary

The analysis started by manually creating the transcripts (Appendix D). The addition of non-verbal articulations was omitted from this experiment due to the considerably impact activity would have had on the knowledge acquisition bottleneck (detailed in section 3.2.1). The SME's commentary served to generate a large amount of protocol, in which the knowledge engineer documented in his notes.

Arm-bar

In providing the SME with clips to critique, the SME's observations were mainly concerned with strategic knowledge of when the arm-bars are applied. Five strategies were identified during the process, a counter to an escape from the mount, one arm-bar from the mount, an arm-bar from the triangle, and an arm-bar from the guard and an innovative transition from the *kimura* arm-lock into the arm-bar. In terms of the procedural knowledge involved in performing the techniques, a few insights are offered however full accounts of the procedural knowledge are not.

Tai-Otoshi

The *tai-otoshi* commentary produced similar results to the arm-bar commentary in that it mainly elicited strategic knowledge of when the *tai-otoshi* could be applied. In the

commentary elicitation, the SME identified four different ways in which it could be applied, the traditional, the non-traditional, left handed and one where the opponent was walking on to the opponent. Once again no procedural information was added with this technique.

6.2.5.4Analysis of the Triadic Elicitation with use of Video Technology

Whilst the creation of the triadic elicitation session was the most problematic, the analysis was perhaps the most simple from the analysis the following insights were gained. From the knowledge engineers analysis, the following insights were gained:-

Arm-bar

Table 6.1 contains the results from the experiment. In analysis the results, this technique elicits the factors of importance in observing the arm-bar techniques. From this it is clear that the SME's consideration factor is from where the technique was performed and to a lesser degree how the technique was performed.

Tai-otoshi

In table 6.2, we see the results of the experiment. In analysis of the results, this technique elicits the factors of importance in the SME's observing the *tai-otoshi* technique. In comparison to the arm-bar triadic elicitation results, it is clear that the SME's consideration factor varied significantly. In total 6 different factors were identified.

Demonstration	Difference	Decision Making Insight
1	The two selected were both performed from	Where the techniques were
	standing positions whilst the other was	performed from
	performed on the ground.	
2	Two were selected because they started from the	Where the techniques were
	ground position, the other one was different	performed from
	because it started from the mount	
3	Two were selected because they had a sweep	Where the techniques were
	into arm-bar, the other one was different because	performed from
	it started from the mount	
4	Two were selected because they used the weight	What contributed to the
	of the attacker to pull them to the ground. The	application of the arm-bar
	other started in the mount	
5	Two were performed from the mount. One was	Where the techniques were
	performed while jumping in the air.	performed from
6	Two from the arm locks from the bottom	Where the techniques were
	position. The other was from the ground.	performed from
7	Two were rolled into from different positions.	How the techniques were
	The third was a triangle choke which converted	performed
	into an arm-bar.	
8	Two from the arm locks from the bottom	Where the techniques were
	position. The other was performed from	performed from
	standing.	
9	Two were rolled into from different positions.	How the techniques were
	The third was a triangle choke which converted	performed
	into an arm-bar.	
10	Two started on their back. The other was	Where the techniques were
	performed from standing	performed from

 Table 6.1 Results from the Triadic Elicitation Armbar experiment

Demonstration	Difference	Decision Making Insight
1	Two were selected as they were performed with	Method used in using the throw
	the grips on both sides of the gi (tai-otoshi	
	variation 2)	
2	Too were selected because they were not	Method used in using the throw
	traditional tai-otoshi throws (one was more like	
	harai-goshi, the other was a combination).	
3	Two were traditional tai-otoshi's done on the	Method used in using the throw
	left hand.	
4	Two were right handed throws, one was left	Positioning on the hands
5	Two were one sided grip, one was traditional	The grips that were used
6	The opponent comes on top to the throw, the	How the throw is setup
	other is a fight for the throw	
7	The opponent comes on top to the throw, the	How the throw is setup
	other is a fight for the throw	
8	In two, the opponent opens up and then drops	How the throw is setup
	for the <i>tai-otoshi</i> , the other the	
9	In two, the foot is placed on the ground in front	Positioning on the legs
	of the opponent	(procedural knowledge)
10	One is an easy <i>tai-otoshi</i> , the others are more	Simplicity of the movement
	complex	

Table 6.2 Results from the Triadic Elicitation Tai-otoshi experiment

6.2.5.5Analysis of Cognitive Walk-through

As with the other techniques, the analysis started with the creation of transcripts (See appendix D) and the addition of non-verbal articulations for both the armbar and the *tai-otoshi* (an example of which is located in appendix E). As the length of the experiments was significantly less than the initial demonstrations, this took significantly less time. From the knowledge engineers analysis, the following insights were gained:-

Arm-bar

The demonstration started at the same point the SME started his verbal articulation in the initial demonstration, in the seated position. In this demonstration, the nine steps identified in the first demonstration were performed. However step 4 in the initial demonstration is now step 1. It is assumed that this can be performed interchangeably. This time three additional steps were verbalised (shifts his weight to his left hand side. This breaks the opponents grip. The SME shifts his weight back to the centre whilst holding the arm at the wrist). As the technique started in the seated position, the experiment gained no strategic knowledge, non-verbally identified in the initial demonstrations.

Tai-otoshi

The *tai-otoshi* cognitive walkthrough saw the SME performing a demonstration of the non-traditional version of the *tai-otoshi*. Two of the seven steps were verbally identified and five, non-verbally. The demonstration was shown from two angles which permitted the non-verbal articulations to be easily observed.

6.2.6 Comparison of Techniques

From the findings, based on the results that have been uncovered from using the techniques a series of graphs has been developed. In this section, the knowledge elicited from the techniques will be compared in six different ways.

- Comparing the coverage of each elicitation in relation to the steps required to perform the arm-bar technique.
- Comparing the strategic knowledge found using each technique for the arm-bar
- Comparing the coverage of each elicitation in relation to the steps required to perform the *tai-otoshi* technique.
- Comparing the strategic knowledge found using each technique for the *tai-otoshi*
- Comparing the number of terms used by the SME, during the course of our elicitation process, from the initial term list.
- Looking at the terms generated which were elicited from the SME during the elicitation process in respect to the techniques.

6.2.6.1 Arm-bar Application

The first way, in which the knowledge elicited from the experiments can be compared, are in the steps required to perform the techniques. For the basis of the comparison of the initial demonstration, the output-input-middle method and the cognitive walkthrough method have been selected. In these results, triadic elicitation and commentary methods were eliminated from the results as they were shown not to identify procedural knowledge of theses steps.





Figure 6.16 Comparison of Arm-Bar Steps

In the initial demonstration of technique, nine steps were identified, six were articulated verbally and three non-verbally. As we see in the results in figure 6.16, the cognitive walkthrough not only identified the nine steps but the steps were verbally identified. With the OIM two methods were demonstrated in the application of the arm-bar as one of the techniques offered a variation of the arm-bar demonstrated in the initial demonstration, the arm-bar from the knee-ride was eliminated from the results. In the demonstration from the mount, five of the nine steps were used of which only one step was identified verbally whilst the other four steps were non-verbally communicated.

6.2.6.2Arm-bar Strategy

The second way in which the elicited knowledge can be compared is the way in which the arm-bar can be employed. From the experiments, the following methods have been compared the initial demonstration, and output-input-middle method. As the cognitive walkthrough was performed from the position of arm-bar application, it offered no strategic knowledge of when the arm-bar could be employed therefore it was eliminated from this section of the results. The results from the triadic elicitation could not be compared in this method as it was not the goal of the technique





Figure 6.17 Comparison of Arm-bar Strategies

In the initial demonstration, three methods were identified non-verbally i.e. from the knee ride position, from the mount position and from the guard position. In the OIM method, two techniques were shown both of which were articulated. From the commentary method, we saw five different variations of the arm-bar being applied.

6.2.6.3 Tai-Otoshi Application

In comparing the steps required to perform the *tai-otoshi* throw, the initial demonstration, output-input-middle method and cognitive walkthrough method. Once again the results from the triadic elicitation method and the commentary method have been eliminated due to the limitations discussed in section 6.2.6.1.





Figure 6.18 Comparison of Tia-Otoshi Steps

In the initial demonstration of the *tai-otoshi*, the technique was demonstrated twice, once from traditional grips and the second one from non-traditional grips. As the techniques demonstrated in the output-input-middle method and the cognitive walkthrough were demonstrated using the non-traditional method, the traditional method was eliminated from this comparison. In the initial demonstration of the *tai-otoshi*, seven steps were identified, but only two were verbally articulated in that demonstration. However it should be noted that more of the procedural steps were articulated in the demonstration of the traditional version. Taking this into account, five were identified. As can be seen in the results in figure 6.18, the initial demonstration was superior to the elicitation methods. In the Cognitive walkthrough, two were verbally identified and the other five, non-verbally. In the OIM, four were identified and three non-verbally.

6.2.6.4Tai-Otoshi Strategy

Comparison of the strategies of the ways in which the *tai-otoshi* throw could be performed was performed using the initial demonstration, output-input-middle method, the commentary method and the cognitive walkthrough method.



Figure 6.19 Comparison of Tai-Otoshi Strategies

The initial demonstration identified two ways in which the throw could be performed using the non-traditional grips and traditional method grips. Whilst the cognitive walkthrough and the output-input-middle methods only generate one each, the commentary method identified four from the five examples shown.

6.2.6.5 Terms from initial term list used

At the start of the experiments we created a list of terms from online sources. We can compare the various techniques can be compared in order to identify which elicitation method benefited most from this list.



Figure 6.20 Comparison of Terms Used

In figure 6.20, we can see that once again, that the SME used most of the terms whilst using the triadic elicitation. By contrast, in performing the cognitive walkthrough the SME did not use any of the terms.

6.2.6.6New Terms Generated

During the experiments, it was possible to construct a list of terms from the various experiments. For this it was possible to compare all of the methods which used the new terms.



Figure 6.21 Comparison of Terms Generated

From the results in figure 6.21, it is clear that most of the terms which were generated as part of the experiments, were generated by the SME were as a result of the triadic

elicitation method. The initial demonstration and cognitive walkthrough generated the least.

6.3 Critical review of experiments

In the following section, a critical review of the steps performed, during the course of the experiments, will be undertaken. In performing this, the reader shall be presented with a critical overview of the factors which contributed to the outcome of the experiments. In addition to the review, this section will also identify possible ways of mitigating the problems, experienced in this iteration, in future iterations. In section 6.3.1, the decisions made in terms of the creating the right environmental conditions for the experiments will discussed. Section 6.3.2 will critically analyse the process involved in the creation of the initial terminology list. This will be followed by an examination of the steps involved in capturing the initial demonstration of the elicitation methods used during the experiments will be critically compared.

6.3.1 Review of Environmental Conditions for the Experiments

The location served as a good environmental to perform the experiments as it was in a location that was familiar to both the knowledge engineer and to the SME. Performing the experiments in and around scheduled classes had the benefit of further reducing pressures on the SME. It also provided the research with a number of students who assisted in the knowledge elicitation experiments. However in performing this during class time meant that the SME was easily distracted and not necessarily consistently focused on the experiments.

6.3.2 Review of Term List

The creation of a terminology list during the knowledge elicitation experiments helped create a valuable resource to be used during the course of the experiments. The initial list was generated using the internet-based resources. This made the experiment repeatable. The creation of the list was successful in identifying nouns however the technique was less successful in identifying verbs and modifiers (i.e. adjectives). As seen in practice, many of the terms which were illustrated during the course of the experiments were not identified during the course of the experiments. The process of adding to the list during the various steps in the knowledge elicitation session provided a better means of capturing the language used in Team Ryano.

6.3.3 Review of capturing the Initial Demonstrations

In capturing the initial demonstration, the filming of the first arm-bar experiment served as a learning experience for the knowledge engineer as the problems associated with fixing a camera in single spot became evident and the difficulties associated with observing the non-verbal dialog from a single position. It was fortunate that the SME moved to favourable positions so that the intricacies could be captured.

The demonstrations themselves were not as focused on specific techniques as they should have been. In giving the SME the freedom to perform the techniques are he would typically do in a class situation, the level of articulation required was considerably less due to pre-requisite knowledge that the students at Team Ryano possess.

6.3.4 Review of Knowledge Elicitation Experiments

In the following section, we will review the individual techniques performed during the elicitation sessions: the OIM, Commentary, Triadic, Cognitive Walkthrough elicitations.

6.3.4.1 Review of the Output Input Middle elicitation

In performing the OIM, several issues were encountered. Because of time limitations on the SME, the performance was somewhat rushed. This resulted in an incomplete elicitation occurring during the *tai-otoshi* demonstration, in which the SME failed to verbally identify the input conditions for the task. In the arm-bar demonstration, the starting conditions were identified. For both experiments, the goals were stated in both experiments. In the performance of the middle, the experiment did not generate a significant amount of verbal articulation. However the camera was able to capture the non-verbal articulations. Despite the relatively little verbal dialog in both, the process resulted in the generation of some useful terms for the terminology list.

6.3.4.2 Review of the Commentary elicitation

In setting up the commentary experiments, significant time was taken by the knowledge engineer in locating video sources online. The commentary experiments only focused on the use of techniques successfully performed. It was expected that the critiquing of failed techniques would have generated more insightful critiquing from the SME. However locating these sources on the Internet is problematic due to fact that people rarely post examples of their techniques being performed poorly. However the use of Internet sources offered the opportunity that these experiments could be easily repeated. The use of CamStudio in capturing the verbal articulations was also successful in its simplicity of use

In terms of SME involvement, the technique successfully generated verbal articulations. Although the technique took the SME outside of his natural environment, the SME seemed to enjoy watching the techniques being performed and the corresponding critiquing process. The process helped generate new terms for the terminology list.

6.3.4.3 Review of the Triadic Elicitation demonstration

The triadic elicitation method used in the experiments was the most difficult of all the experiments to perform. As with the commentary experiment, the video clips focused on the performance of successful techniques. In creating the experimental set for the experiments, seven additional ones were found and used with the ones found in the commentary experiments. This helped reduced the time to setup the experiment. In

selecting the three clips to be viewed by the SME, the use of random selection made the experiments unbiased. Despite the relatively small set of clips selected, efforts were made to ensure that the clips were shown no more than three times and no less than twice.

Initially in performing the experiments, there were problems in the terms of the speed in which they were performed due to trail version of the cSwing software which was used. This was later successfully rectified by prerecording the triadic elicitation selection and then playing them using RealPlayer.

As with the commentary experiment, the experiment succeeded in generating verbal articulations for the analysis phase and resulted in five new terms being generated. In retrospect, the inclusion of this experiment offered little to the overall goal of the experiments, but did serve as a useful indicator that not elicitation techniques can be adapted to any situation.

6.3.4.4 Review of the Cognitive Walkthrough Elicitation

In this technique, the experiment had mixed fortunes. The arm-bar demonstration benefitted from the camera close the actual demonstration as well as the SME's excellent verbal articulations during the course of the demonstrations. Unfortunately the *tai-otoshi* demonstration suffered from being removed from the actual demonstrations as well as the camera being located in a fixed point

6.4 Overall Critical Review

In reviewing the methodology it is important to critically examine the various lessons learnt from the course of the experiments.

In selection of the martial arts techniques, the research focused on two common techniques that were taught and used at Team Ryano. These two techniques were significantly different. The arm-bar is a submission technique that is commonly used

in the sports of MMA, BJJ, Judo and Submission Wrestling. This technique can be performed dynamically in its application but can be slowed down and each step articulated with relative ease. The throwing technique, *tai-otoshi*, is much more dynamic in nature. This made articulation significantly more difficult to perform and analysis even more problematic. Whilst the methodology was shown to work for both techniques, the analysis required for the *tai-otoshi* was a greater undertaking.

For the purposes of our experiments, a single SME was used in the knowledge elicitation process. This source was not only had a rich source of knowledge from his participation in various martial arts but was also willing to engage in the experiment process. The SME performed all the tasks required of him despite occasional work pressures. In retrospect, the experiments would have benefited from being conducted outside of scheduled practice. However his involvement was essential in the research and as a means of facilitating his involvement, compromises had to be made.

In selecting the knowledge engineer for the purposes of our experiments, we had an individual with knowledge of the Team Ryano organisation and an existing relationship with the SME. This relationship enabled full co-operation of the SME in the various experiments. In his approach to the knowledge capture process, his involvement was to record and observe the experiments whilst avoiding interrupting the SME in his demonstrations. This approach limited the way in which additional insights could be gained but it proved to be a more natural approach in which the SME felt comfortable with. The knowledge engineer was also responsible for the retrospective analysis of the captured knowledge. The insights gained from the analysis might have been slightly biased due to existing knowledge of the sport possessed by the engineer; however this knowledge was essential in the identification of nuances required to break down the steps of each individual technique. As identified in section 3.3.3, using a knowledge engineer without this prerequisite knowledge of the knowledge domain is problematic.

An interesting aspect of the research came in the creation of the terminology list. The list in itself captured the common language used in the organisation. This research illustrated how the tacit language of the various groups at Team Ryano could be made explicit. In our list, we not only captured nouns but also verbs. In the creation of the initial terminology list from online-sources, we were only able to gather three verbs. From the limited work, we were able to capture five. This serves as an indicator of the limitations of the existing online term repositories. In creating a common terminology for the sport, all syntactic types must be captured.

The selection of the knowledge elicitation techniques is an empirical and iterative process (Cooke, 1994). In our investigation, we initially select five methods. Due to concerns that the teach-back technique would be biased by knowledge engineers previous experience in the sport, this was omitted from final selection. This method would have better suited a situation whereby a knowledge engineer with no experience in the field was used. In selecting these techniques, many of them were adapted from their original use. This approach provided much discussion during the experiment phase. In terms of the goals established at the onset of our experiments, the triadic elicitation variation failed to elicit knowledge that aided the capture of strategic or procedural knowledge pertaining to the techniques. The results from this technique served more to detail the important factor a SME might consider when observing variations of the techniques being performed. The findings from our experiments are of great interest but not in the context of the goals established at the onset of our research. From our results, the cognitive walkthrough in the arm-bar experiment was particularly successful in generating verbal articulations. The output-input-method was less successful in the arm-bar demonstration as fewer steps were identified in terms of the steps. The commentary elicitation provided a good source for the identification of strategic knowledge in terms of when these techniques can be employed. The results from this experiment are a useful tool for practitioners in identifying situations in which techniques can be employed. One way in which the commentary could have been improved would have been the inclusion of failed attempts in performing the techniques. An initial investigation into acquiring these types of techniques from online sources was attempted. Finding examples of error in performance was difficult as it seemed that practitioners are unwilling to post examples of poor technique. Extensive analysis of videos would have been required in this task which would have resulted in a significant impact on the knowledge acquisition bottleneck. It would have also made the experiments more difficult to repeat.

In capturing the initial demonstrations and elicitation techniques varied in its complexity. The initial demonstrations, the output-input-method and the cognitive walkthrough only required the use of video equipment and video editing software. The triadic elicitation and the commentary, required more preparation. In finding the techniques to observe, sources had to be obtained online. This involved some degree of pre-processing as well as use of a laptop and recording software in order to perform the experiments. This had a negative impact of the bottleneck. There were also concerns with the fixed position of the camera during the initial demonstrations. However this was rectified and improved the quality of the video captured which contributed to reducing the difficulty faced in analysis.

The capture process itself generated a significant amount of protocol which had to be analysed. The retrospective analysis of the captured data was aided through video software that enabled the techniques to be observed at slower speeds so that each individual step could be analysed. The process was also assisted through the use of transcripts which aided the identification of verbal and non-verbal analysis. The analysis of video is a particularly time consuming activity. It would have been interesting to examine fields such as physical task analysis and sports science in order to gain deeper insights to process.

From the analysis, it was possible to elicit the steps involved in performing the techniques. In using the elicitation techniques were also able to articulate steps which are inherently difficult to grasp through normal observation and practice. The analysis also identified strategic knowledge in which these techniques could be performed. The process also identified and elicited parts of the previously tacit common language used in Team Ryano. These terms were defined in our terminology list (Appendix D) and can be included as part of the initial terminology list constructed (Appendix C). In eliciting this knowledge, we have created valuable knowledge artefacts which can be used at Team Ryano.

In future work in the field could look at eliciting different types of knowledge from within Team Ryano. Whilst procedural knowledge is important, the externalisation of

knowledge which exists in the decision making process would be of enormous benefit to all of the students at Team Ryano. If externalised and distributed through out the organisation, it would benefit all students within the group.

6.5 Conclusions

In this chapter we detailed the experiment process in section 6.2. From our results we were able to see that procedural and strategic knowledge was elicited our domain expert. In addition to tacit knowledge, knowledge of the terminology used in the field was also elicited. This was followed by a critical review of the experiments in section 6.3. The chapter was concluded with an overall critical review of the process in it entirety in section 6.4.

In order to put the thesis in context with the themes discussed in this chapter. The thesis is concerned with the elicitation of knowledge from a SME in the field of MMA. In eliciting knowledge, experiments were conducted (section 6.2) following the methodology detailed in chapter 5. Once performed, each individual aspect of the elicitation process was then critically analysed (section 6.3). The methodology was then analysed with reference to the initial research questions posed (section 6.4).

7 CONCLUSIONS AND FUTURE WORK

"Finally, in conclusion, let me say just this."

Peter Sellers

7.1 Introduction

The aim of the research was to investigate the use of knowledge elicitation (KE) techniques, traditionally used to capture knowledge at a cognitive level, and to apply it to the acquisition of physical skill based knowledge. As means of achieving this, a KE initiative was conducted in which KE techniques were applied to the elicitation of skills required to perform mixed martial arts (MMA) techniques from an expert in the field. In performing this research, it was envisaged that the research would identify the applicability of these techniques to the problems faced by knowledge engineers in acquiring knowledge about physical skill acquisition. This chapter will present a summary of the key findings in reference to the aims and objectives detailed at the onset of the research in section 7.2. The chapter will be concluded with a discussion of the potential for future work (in section 7.3) and a closing summary in section 7.4.

7.2 Conclusions

At the beginning of this thesis, several objectives were established in section 1.4. This section will look at each object and detail how each one was addressed. This will then be followed by a presentation of some of the key findings from each of the objectives. The section will be concluded with an overview of the overall conclusions from the research.

7.2.1 Overview Of Knowledge Management

The first objective of the work was to provide an overview of the field of knowledge management (KM). This was achieved in chapter two. The chapter commenced by

defining knowledge in two ways. The first was by differentiating it from data, information and wisdom through the use of the DIKW pyramid and providing definitions from KM literature (section 2.2.1). The chapter then focused on providing an overview of the different categorisations of knowledge in which various characteristics are used to order knowledge (section 2.2.2). This was then followed by a view of knowledge within an organisation by identifying entities in which it resides (section 2.2.3). This was followed by a discussion of the various models used to organisational knowledge learning. The field of Knowledge Management was then discussed (section 2.4) and defined in reference to the wide variety of definitions that exist throughout literature (in section 2.4.1). KM models were then discussed (section 2.4.4) and the section concluded through a high level overview of the knowledge processes that exist (2.4.5). The following list highlights some of the key findings from the section.

- In order to fully understand the field of KM, it is important to understand what is meant by knowledge. The literature review revealed numerous definitions of the term. Whilst these definitions are useful, the DIKW model provides a powerful means to clearly define knowledge in reference to other cognitive representations (detailed in section 2.2.1). This clear delineation is important for the field of KM and helps differentiate KM initiatives from the ones from Information Management (indentified in section 2.4.3).
- A means of understanding the characteristics of knowledge can be achieved by examining the different characteristics. In section 2.2.2, the reader was introduced to three distinct categorisations, Nonaka's categorisation of tacit and explicit knowledge (in section 2.2.2.1), Bennet's taxonomy (in section 2.2.2.2), and Awad and Ghaziri's notion of procedural, declarative, semantic and episodic knowledge (in section 2.2.2.3). For the most part, KM literature deals with Nonaka's delineation between tacit and explicit knowledge as a means of classifying knowledge. However in selecting knowledge to be captured as part of a KM initiative, this categorisation in itself is not enough. In using Bennet's taxonomy, it facilitates the identification of knowledge). Whilst using Awad

and Ghaziri's categorisation, it allows knowledge to be considered in terms of its representation. Simply stating that because knowledge is tacit it is worthy of the time and expense required to elicit the knowledge is not enough. Only a systematic approach, whereby all these categorisations are factored in, can a mechanism to identify valuable knowledge be established.

- In terms of an organisation, knowledge exists in various entities (section 2.2.3). In this chapter, we categorised these locations in terms of individuals, groups, the organisation as a whole, and externally to an organisation. This recognition is important as it supports the concept of silos of knowledge, whereby knowledge is stored in multiple locations both internally and externally to an organisation. In order to facilitate it transit to locations where this knowledge is needed, organisations must identify where these entities exist and the knowledge that they possess.
- In defining an expert, we made the linkage between the various knowledge components and expertise. Being able to make sense of data, information and knowledge pertaining to a specific field of endeavour, requires expertise. This linkage is important as it can also provide a means of understanding how expert behaviour can be achieved i.e. through the acquisition of expertise.
- In organisational learning, various models exist which attempt to model this behaviour. Whilst most of the KM literature used the SECI model to illustrate this, section 2.3 acknowledged the existence of other models which exist (i.e. the apprenticeship model and Choo's Organisational Knowing Model). The other models differ significantly from the SECI model. In understanding these differences, the reader is made aware of limitations of each.
- Difficulties arise in defining Knowledge Management. From the literature review, the reader was introduced to the multitude of perspectives that exist. Used in isolation, these definitions rarely encapsulate the totality of the field. It has been argued that these perspectives are largely dependent on the context in

which they aim to serve. However with an appreciation of these perspectives, it is possible to gain a high-level overview of the various perspectives.

• As with the multiple definitions of KM, the models used in KM also differ significantly. Despite all their differences, there appears to be several recurring themes that are present in many of the models. The first is that there appears to be convergence between the different processes used by the various models. Section 2.4.5, divided the processes used by the models into four distinct categories, knowledge discovery, knowledge capture, knowledge sharing, and knowledge application. Second is that KM is that the KM lifecycle is an iterative process. By continually adhering to the knowledge processes, an organisation's knowledge assets will grow accordingly.

7.2.2 Overview of Knowledge Elicitation

The second objective was to identify of relevant work done, to date, in the field of knowledge elicitation. In this chapter, we defined of knowledge acquisition (KA) looking at the various subsets of the subject as well as the issues which affect each type in the acquisition of knowledge. From this the focus shifted to the subject primarily concerned with the elicitation of knowledge from a human expert, known as knowledge elicitation. An overview was provided of the area, looking at the various influences which have directed research in the area. The issues and requirements for KE were addressed. We looked at various classifications of KE and finally identified the use of KE in terms of the Knowledge Capture process (identified in section 2.4.5.2). The following list highlights some of the key findings from the section.

• In literature, the terms knowledge acquisition and knowledge elicitation are often used interchangeably. There is however a clear delineation between the two. Knowledge Acquisition is concerned with the high level acquisition of knowledge from knowledge sources whilst knowledge elicitation is primarily concerned with the acquisition of knowledge from human sources. In a new and emerging field such as KM it is important that a clear delineation.

- In examining the issues which need to be addressed in knowledge acquisition, we looked at the knowledge acquisition bottleneck. These issues can be put into three broad categories, narrow bandwidth, acquisition latency and knowledge inaccuracies. These are the three major contributing factors to the difficulties associated with the knowledge acquisition process. The issues contained within each must be carefully managed to ensure the success of knowledge management initiatives. As KE is part of KA, it makes sense that the issues associated with KE are in part inherited from that of KA. In this context however, not all the issues in KA are relevant to KE.
- There are three major categories of knowledge acquisition tools, automated knowledge acquisition tools, semi-automated knowledge acquisition tools and manual knowledge acquisition tools. All of these methods have their benefits and their flaws. The selection of the appropriate method is based on the aspects of the knowledge acquisition bottleneck which are most problematic.
- The field of KE finds its roots in many different fields. The field as we know it today has been influenced by the fields in which it has been applied to. Despite the infancy of the field, KE has always existed in one form or another. Further lessons learnt in history can not only be attributed to research learnt in the field of expert systems but can in fact date back centuries.
- This chapter identified and categorised issues associated with KE into three distinct categories, issues in initialising the KE process (section 3.3.2.1), issues in selecting appropriate KE techniques (section 3.3.2.2) and issues that exist whilst performing the KE process (section 3.3.2.3). In resolving the issues, it is necessary to identify requirements which must be adhered to in order to resolve the issues (section 3.3.3). Deviation from these requirements can result in impact on the knowledge acquisition bottleneck.

7.2.3 Background to Mixed Martial Arts

The third objective of the work was to provide a background to mixed martial arts (MMA), the context in which the study would be performed. Chapter four provided an overview of the sport by first looking at the evolution of the sport from its historical roots through to the modern age (in section 4.2). The chapter then focused on the local Irish MMA scene and detailed the growth of the sport on a national level. The chapter was concluded with an examination of the Team Ryano organisation from a knowledge management perspective (in section 4.3). In this, the locations of knowledge and the means in which knowledge was created and distributed, both internally and externally to the Irish community, were detailed. The following list highlights the key findings from the section.

- The business of MMA has much in common with other fields of endeavour, thus making the application of KM techniques as relevant in this field as any other. MMA organisations have an abundance of knowledge in all aspects of their business. In section 4.3, we saw that knowledge at Team Ryano was required at all levels of the organisation. From its use in the coaching of its individuals all the way through to the performance of its everyday administrative tasks. As with other industries, commercialisation has seen the potential financial gains increase (detailed in section 4.2). With so much at stake, organisations must look at ways in which organisational knowledge can be exploited in order to gain a competitive advantage.
- The rules in which a combat sport is played effects the strategies involved in applying the techniques. Whilst the procedural knowledge used in applying the MMA techniques are often derived from other martial arts (e.g. BJJ, Thai-Boxing, Judo, *etc.*), however when used within in the sport of MMA, the strategies and tactics used to enable a fighter to apply these techniques are different. For example, the rules in MMA allow striking whilst an opponent is in the guard position. This makes it dangerous for a competitor in the bottom
position to apply an arm-bar. However in Judo, striking an opponent is illegal therefore a competitor applying an arm-bar from the bottom position is relatively safe.

• Whilst the acquisition of martial arts skills is generally acquired through the processes detailed in the apprenticeship model (detailed in section 2.3.1), skills are often acquired using processes described in other models. For example, the early Irish practitioners of MMA used a model in keeping with Choo's sense making process (detailed in section 2.3.2) whereby individuals used a wide variety of knowledge artefacts acquired from extra-organisational sources and collaborated with other individuals to empirically test the techniques. This process has much in common with Nonaka's socialisation process (detailed in section 2.3.3).

7.2.4 Conducting the Experiments

The next objective was to conduct experiments, in which KE techniques, found in the literature review, were then applied to the acquisition of mixed martial arts techniques. In order to achieve this, an experimental design was developed in chapter 5. The chapter started by establishing the research question (in section 5.2) and identified the goals of the research by looking the questions which were raised as a result of the research question (in section 5.3). Once established, the requirements for the experiments were detailed (section 5.4) and the methodology and design selections were made (in section 5.5 and section 5.6). The experiments were then conducted and detailed in chapter 6. This section detailed the steps detailed the initial steps taken in the preparation for the experiments (in section 6.2.1), the steps taken to create the initial dictionary of terms, a detailed account of process required to capture the initial demonstrations (in section 6.2.4), and finally the retrospective analysis of the initial demonstration and KE captured sessions (in section 6.2.5). From this phase, it is possible to draw some conclusions from the process.

- When conducting knowledge elicitation sessions using a single expert, the selection process is particularly important. The scope of the initiative is limited to the size and complexity of the domain of an expert's knowledge (McGraw & Seale, 1988), therefore it is important to ensure the subject matter expert knowledge encapsulates the entirety of the knowledge which needs to be elicited.
- Whilst some of the KE techniques could be applied to the elicitation of physical skills, some techniques need to be altered somewhat in order to make them applicable. For example, the triadic elicitation method which was used in the experiments differed significantly from its traditional use. Normally this method is used with cards representing concepts in the domain. In the experiments, the cards were replaced with video clips representing variations of the techniques being elicited. Whilst the fundamental goal of the technique remained the same, the way in which it was implemented altered.
- Using a knowledge engineer, who has expert knowledge of the domain, can often preclude them for involvement in some of the knowledge engineering techniques. This was illustrated in the removal of the Teach Back method from the experimental set (in section 6.2.4.5). The method required the knowledge engineer to perform back the steps to SME which was representative of the elicited knowledge from the sessions. However due to his experience in the field it would have been difficult to assess whether the performance was as a result of the knowledge elicitation or from previous experience.

7.2.5 Analysis of Experimental Results

The next objective was to perform a critical analysis of the results. To achieve this, results from the elicitation sessions and the initial demonstrations of technique were presented and compared in six different ways. In section 6.2.6.1, the initial demonstration of technique was compared against the elicitation techniques in terms of the procedural steps required to perform the arm-bar technique. The results highlighted which techniques that successfully assisted the expert in verbally articulating the steps.

A similar comparison was made in terms of the *tai-otoshi* technique in section 6.2.6.3. Section 6.2.6.2 looked at the elicitation of strategic knowledge for the arm-bar technique whilst section 6.2.6.4 looked at the elicitation of strategic knowledge for the *tai-otoshi* technique. As with the comparisons of procedural knowledge, both MMA techniques were compared and the results presented in terms of steps verbally articulated by the expert. The final set of results was concerned with the acquisition of terminology from the experiments. In section 6.2.6.5, the techniques were compared in order to assess which methods benefited most from the terminology list generated from online sources at the start of the experiments. Finally in section 6.2.6.6, the methods were compared in order to identify the techniques which were responsible for introducing new terms into the terminology list. From the results, we were able to provide the following findings.

- In the comparison of the steps required to perform the arm-bar technique, the cognitive walkthrough performed well. Not only did it manage to capture the steps identified in the initial demonstrations but it also assisted the SME to articulate each step. Unfortunately in the same technique when used in the elicitation of the *tai-otoshi* throw did not perform as well. It appears that the dynamic nature of the throw means that the performance of the throw is impacted when the SME is required to articulate each step. It is envisaged that a retrospective cognitive walkthrough of the technique being performed by the expert would allow the SME to slow down the footage and provide a commentary on the actions being performed.
- In terms of the strategic knowledge for the arm-bar and the *tai-otoshi* technique, the commentary method succeeded in eliciting the most variations in which the techniques could be performed. This can be attributed to the wide variations of technique that were available from the internet sources. This finding is important as it demonstrates how traditional knowledge acquisition can be supplemented by extra-organisational sources.
- The results show that the techniques that benefited most from the generated terminology list were the KE techniques which produced the largest amount of

generated protocol (i.e. the triadic elicitation and commentary methods). As the SME can not physically articulate concepts as with the demonstration and the cognitive walkthrough, it appears that these methods forces the SME to articulate more. Where concepts cannot be explained in layman's terms, domain specific terms must be used.

• Similarly in generating terms from KE sessions, KE techniques which result in a large amount of generated protocol were seen to generate the most numbers of terms. In using these techniques, the SME is once again forced into articulating more and generating more protocol in which terms associated with the field are used.

7.2.6 Analysis of Process

The next objective was to reflect on the process used to conduct the experiments. In section 6.3, a critical review of the each element of the methodology was performed. The decisions made in terms of the creating the right environmental conditions for the experiments were discussed in section 6.3.1. Section 6.3.2 critically analysed the process involved in the creation of the initial terminology list. This was followed by an examination of the steps involved in capturing the initial demonstration of technique in section 6.3.3. Section 6.3.4 analysed each of the elicitation methods used during the experiments. Finally in section, 6.4, the entire process was analysed in its entirety. From this the following conclusions were made.

- In the selecting techniques for the knowledge elicitation process, it is important that the techniques selected are appropriate for the goals of the research. As we saw in section 3.3.4, there exists a wide variety of knowledge elicitation techniques all used to elicit different types of knowledge (section 3.3.4.4). As we saw in the triadic elicitation experiments, the method failed to elicit knowledge pertaining to strategic or procedural knowledge.
- Involvement in knowledge elicitation sessions within an organisation, the terminology used to explain terms and concepts are an important aspect of the

process. In this using them, the gap between the SME's demonstration of knowledge and the knowledge engineer's understanding of the concepts being demonstrated can be reduced, thus the elicitation techniques allowed the knowledge engineer to work within Vygotsky's "zone of proximal development".

- As mentioned in section 3.2.2.1, a survey estimated that over 90 percent of organisational knowledge resides tacitly, but using knowledge elicitation techniques it was possible to make some of the tacit knowledge explicit specifically through the development of the terminology list, and the videoed elements.
- When conducting knowledge elicitation at the SME's place of work, it is important that an appropriate time is scheduled. In the experiments in order to facilitate his inclusion, the sessions were scheduled around class times. In doing this we saw that it was difficult the get the adequate time for the sessions and therefore some of the experiments did not have the same quality as the others.

7.3 Future work

The research performed serves as a good foundation in which future elicitation sessions can be performed, learning from the lessons of the experiments.

- In the experiments, each elicitation method was only done once. Future experiments could look at performing the same experiment multiple times to test to see if the same or similar results are experience each time. This research could form the basis of research into reliability of knowledge elicitation techniques, an important factor in selecting a tool.
- Further experiments could be conducted focusing on eliciting more of the organisation's tacit knowledge. The strategies and the techniques used at Team Ryano are of great importance to the individuals within the club. In eliciting

this knowledge and externalising it, this format allows for knowledge to be easily distributed to all members of the groups.

- As we saw by the versatility of the methods during the knowledge elicitation sessions, the methods could be easily used in other martial arts and other sports. Mixed Martial Arts clubs are no different to any other sports club. Due to the physical nature of some sports, knowledge is not normally externalised. Knowledge pertaining to procedural knowledge required to swing a club, or strategic knowledge of when to pass a ball, could be acquired and used for the benefit of the organisation.
- As more and more students at Team Ryano rise from novice status to expert status, there will be the opportunity to use the group elicitation methods (detailed in section 3.4.3.3) such as DeBono six hats of thinking. These methods would bring a greater depth to the externalised knowledge by fostering the opinion of all the participants which in turn would lead to better quality knowledge artefacts which would be of great value to the organisation.
- In its present format, the list of terms could be easily distributed to other members of the Team Ryano organisation and further terms added. Technologies such as Wiki can be employed to foster and develop the construction of terminology not only within a field but also within a community in which a common language exists. These terms are of great importance to the community in which they are used. This common language facilitates the socialisation phase illustrated in the SECI model (in section 2.3.3) thus allowing ideas, concepts and abstractions to be communicated easily.
- In the elicited knowledge, future work could look at be put in a format and used in conjunction with theories from instructional design to create an instructional video based on the findings of the elicitation sessions. This would serve as an organisation tool in which the group knowledge at Team Ryano could be captured in a more appropriate metaphor for distribution.

- As we identified in the creation of the experimental set for the commentary and triadic elicitation methods, it was difficult to find techniques that were being performed badly from online sources. Lots of insights can be gained from watching poor technique in action e.g. strategic knowledge of why a throw could not be performed, procedure knowledge of steps which have been missed. It would be useful to create a demonstration video containing techniques with additional commentary in order to provide even more insight.
- In the literature review, it was seen that the transfer of knowledge is traditionally performed through the apprenticeship model, future work could focus on the effect that explicit sources of knowledge have on the learning process. Even more in-depth research could help to identify, the most appropriate metaphors in which explicit knowledge can benefit students of the sport.

7.4 Summary

This dissertation demonstrated how KE techniques, used at acquiring knowledge at a cognitive level, could be applied to the acquiring knowledge associated with physical skills. It is envisaged that future iterations of the KE could help organisations retain their knowledge assets and facilitate the distribution of knowledge to the community in which they serve. Whilst some of these techniques can be directly applied to a field, some techniques need to be altered somewhat in order to make them applicable. In establishing the requirements, justifying design decisions, detailing the steps performed, providing a set of results and critically analysing the process, the field as a whole can only benefit.

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APPENDIX A: SUMARY OF UNIFIED RULES OF MMA

Weight classes of mixed martial artists

- Mixed martial artists shall be divided into the following classes:
 - Flyweight under 125.9 pounds;
 - Bantamweight 126 lbs. 134.9 pounds;
 - Featherweight 135 lbs. 144.9 pounds;
 - Lightweight 145 lbs. 154.9 pounds;
 - Welterweight 155 lbs. 169.9 pounds;
 - Middleweight 170 lbs. 184.9 pounds;
 - Light Heavyweight 185 lbs. 204.9 pounds;
 - Heavyweight 204 lbs. 264.9 pounds; and
 - Super Heavyweight over 265 pounds.

Fighting area

- The fighting area canvas shall be no smaller than 18 feet by 18 feet and no larger than 32 feet by 32 feet. The fighting area canvas shall be padded in a manner as approved by the Commissioner, with at least one inch layer of foam padding. Padding shall extend beyond the fighting area and over the edge of the platform. No vinyl or other plastic rubberized covering shall be permitted.
- The fighting area canvas shall not be more than four feet above the floor of the building and shall have suitable steps or ramp for use by the participants. Posts shall be made of metal not more than six inches in diameter, extending from the floor of the building to a minimum height of 58 inches above the fighting area canvas and shall be properly padded in a manner approved by the Commissioner.

- The fighting area canvas area shall be enclosed by a fence made of such material as will not allow a fighter to fall out or break through it onto the floor or spectators, including, but not limited to, vinyl coated chain link fencing. All metal parts shall be covered and padded in a manner approved by the Commissioner and shall not be abrasive to the contestants.
- The fence shall provide two separate entries onto the fighting area canvas.

Mouth pieces

- All contestants are required to wear a mouthpiece during competition. The mouthpiece shall be subject to examination and approval by the attending physician.
- The round cannot begin without the mouthpiece in place.
- If the mouthpiece is involuntarily dislodged during competition, the referee shall call time, clean the mouthpiece and reinsert the mouthpiece at the first opportune moment, without interfering with the immediate action.

Protective equipment

- Male mixed martial artists shall wear a groin protector of their own selection, of a type approved by the Commissioner.
- Female mixed martial artists are prohibited from wearing groin protectors.
- Female mixed martial artists shall wear a chest protector during competition. The chest protector shall be subject to approval of the Commissioner.

Gloves

- The gloves shall be new for all main events and in good condition or they must be replaced.
- All contestants shall wear either four, five or six ounce gloves, supplied by the promoter and approved by the commission. No contestant shall supply their own gloves for participation.

Apparel

- Each contestant shall wear mixed martial arts shorts, biking shorts, or kickboxing shorts.
- Gi's or shirts are prohibited during competition.
- Shoes are prohibited during competition.

Round length

- Each non-championship mixed martial arts contest shall be three rounds, of five minutes duration, with a one minute rest period between each round.
- Each championship mixed martial arts contest shall be five rounds, of five minutes duration, with a one minute rest period between each round.

Stopping a contest

• The referee and ringside physician are the sole arbiters of a bout and are the only individuals authorized to enter the fighting area at any time during competition and authorized to stop a contest.

Judging

- All bouts will be evaluated and scored by three judges.
- The 10-Point Must System will be the standard system of scoring a bout. Under the 10-Point Must Scoring System, 10 points must be awarded to the winner of the round and nine points or less must be awarded to the loser, except for a rare even round, which is scored (10-10).
- Judges shall evaluate mixed martial arts techniques, such as effective striking, effective grappling, control of the fighting area, effective aggressiveness and defense.
- Evaluations shall be made in the order in which the techniques appear in (c) above, giving the most weight in scoring to effective striking, effective grappling, control of the fighting area and effective aggressiveness and defense.
- Effective striking is judged by determining the total number of legal heavy strikes landed by a contestant.
- Effective grappling is judged by considering the amount of successful executions of a legal takedown and reversals. Examples of factors to consider are take downs from standing position to mount position, passing the guard to mount position, and bottom position fighters using an active, threatening guard.
- Fighting area control is judged by determining who is dictating the pace, location and position of the bout. Examples of factors to consider are countering a grappler's attempt at takedown by remaining standing and legally striking; taking down an opponent to force a ground fight; creating threatening submission attempts, passing the guard to achieve mount, and creating striking opportunities.
- Effective aggressiveness means moving forward and landing a legal strike.

- Effective defense means avoiding being struck, taken down or reversed while countering with offensive attacks.
- The following objective scoring criteria shall be utilized by the judges when scoring a round;
 - A round is to be scored as a 10-10 Round when both contestants appear to be fighting evenly and neither contestant shows clear dominance in a round;
 - A round is to be scored as a 10-9 Round when a contestant wins by a close margin, landing the greater number of effective legal strikes, grappling and other manoeuvres;
 - A round is to be scored as a 10-8 Round when a contestant overwhelmingly dominates by striking or grappling in a round.
 - A round is to be scored as a 10-7 Round when a contestant totally dominates by striking or grappling in a round.
- (k) Judges shall use a sliding scale and recognize the length of time the fighters are either standing or on the ground, as follows:
 - If the mixed martial artists spent a majority of a round on the canvas, then:
 - Effective grappling is weighed first; and
 - Effective striking is then weighed
- If the mixed martial artists spent a majority of a round standing, then:
 - Effective striking is weighed first; and
 - Effective grappling is then weighed

• If a round ends with a relatively even amount of standing and canvas fighting, striking and grappling are weighed equally.

Warnings

- The referee shall issue a single warning for the following infractions. After the initial warning, if the prohibited conduct persists, a penalty will be issued. The penalty may result in a deduction of points or disqualification.
 - Holding or grabbing the fence;
 - Holding opponent's shorts or gloves; or
 - The presence of more than one second on the fighting area perimeter.

Fouls

- The following are fouls and will result in penalties if committed:
 - Butting with the head;
 - Eye gouging of any kind;
 - Biting or spitting at an opponent;
 - Hair pulling;
 - Fish hooking;
 - Groin attacks of any kind;
 - Intentionally placing a finger in any opponent's orifice;
 - Downward pointing of elbow strikes;
 - Small joint manipulation;
 - Strikes to the spine or back of the head;
 - Heel kicks to the kidney;
 - Throat strikes of any kind;
 - Clawing, pinching, twisting the flesh or grabbing the clavicle;
 - Kicking the head of a grounded fighter;
 - Kneeing the head of a grounded fighter;

- Stomping of a grounded fighter;
- The use of abusive language in fighting area;
- Any unsportsmanlike conduct that causes an injury to opponent;
- Attacking an opponent on or during the break;
- Attacking an opponent who is under the referee's care at the time;
- Timidity (avoiding contact, or consistent dropping of mouthpiece, or faking an injury);
- Interference from a mixed martial artists seconds;
- Throwing an opponent out of the fighting area;
- Flagrant disregard of the referee's instructions;
- Spiking an opponent to the canvas on his or her head or neck.
- Disqualification occurs after any combination of three or the fouls listed in (a) above or after a referee determines that a foul was intentional and flagrant.
- Fouls will result in a point being deducted by the official scorekeeper from the offending mixed martial artist's score.
- Only a referee can assess a foul. If the referee does not call the foul, judges shall not make that assessment on their own and cannot factor such into their scoring calculations.
- A fouled fighter has up to five minutes to recuperate.
- If a foul is committed, the referee shall:
 - call time;
 - check the fouled mixed martial artist's condition and safety; and assess the foul to the offending contestant, deduct points, and notify each corner's seconds, judges and the official scorekeeper.

- If a bottom contestant commits a foul, unless the top contestant is injured, the fight shall continue, so as not to jeopardize the top contestant's superior positioning at the time.
 - The referee shall verbally notify the bottom contestant of the foul.
 - When the round is over, the referee shall assess the foul and notify both corners' seconds, the judges and the official scorekeeper.
 - The referee may terminate a bout based on the severity of a foul. For such a flagrant foul, a contestant shall lose by disqualification.

Injuries sustained during competition

- If an injury sustained during competition as a result of a legal maneuver is severe enough to terminate a bout, the injured contestant loses by technical knockout.
- If an injury sustained during competition as a result of an intentional foul is severe enough to terminate a bout, the contestant causing the injury loses by disqualification.
- If an injury is sustained during competition as a result of an intentional foul and the bout is allowed to continue, the referee shall notify the scorekeeper to automatically deduct two points from the contestant who committed the foul.
- If an injury sustained during competition as a result of an intentional foul causes the injured contestant to be unable to continue at a subsequent point in the contest, the injured contestant shall win by technical decision, if he or she is ahead on the score cards. If the injured contestant is even or behind on the score cards at the time of stoppage, the outcome of the bout shall be declared a technical draw.

- If a contestant injures himself or herself while attempting to foul his or her opponent, the referee shall not take any action in his or her favor, and the injury shall be treated in the same manner as an injury produced by a fair blow.
- If an injury sustained during competition as a result of an accidental foul is severe enough for the referee to stop the bout immediately, the bout shall result in a no contest if stopped before two rounds have been completed in a three round bout or if stopped before three rounds have been completed in a five round bout.
- If an injury sustained during competition as a result of an accidental foul is severe enough for the referee to stop the bout immediately, the bout shall result in a technical decision awarded to the contestant who is ahead on the score cards at the time the bout is stopped only when the bout is stopped after two rounds of a three round bout, or three rounds of a five round bout have been completed.
- There will be no scoring of an incomplete round. However, if the referee penalizes either contestant, then the appropriate points shall be deducted when the scorekeeper calculates the final score.

Types of Bout Results

- The following are the types of bout results:
 - Submission by:
 - Tap Out:When a contestant physically uses his hand to indicate that he or she no longer wishes to continue; or
 - Verbal tap out:When a contestant verbally announces to the referee that he or she does not wish to continue;
 - Technical knockout by:
 - Referee stops bout;

- Ringside physician stops bout; or
- When an injury as a result of a legal maneuver is severe enough to terminate a bout;
- Knockout by failure to rise from the canvas;
- Decision via score cards:
 - Unanimous: When all three judges score the bout for the same contestant;
 - Split Decision: When two judges score the bout for one contestant and one judge scores for the opponent; or
 - Majority Decision: When two judges score the bout for the same contestant and one judge scores a draw;
- Draws:
 - Unanimous When all three judges score the bout a draw; ii. Majority When two judges score the bout a draw; or
 - Split When all three judges score differently and the score total results in a draw;
- Disqualification:When an injury sustained during competition as a result of an intentional foul is severe enough to terminate the contest;
- Forfeit: When a contestant fails to begin competition or prematurely ends the contest for reasons other than injury or by indicating a tap out;
- Technical Draw: When an injury sustained during competition as a result of an intentional foul causes the injured contestant to be unable to continue and the injured contestant is even or behind on the score cards at the time of stoppage;
- Technical Decision: When the bout is prematurely stopped due to injury and a contestant is leading on the score cards; and

• No Contest:When a contest is prematurely stopped due to accidental injury and a sufficient number of rounds have not been completed to render a decision via the score cards.

APPENDIX B: IRISH MMA LEAGUE RULES

Summary

• The event will consist of limited rules amateur MMA matches, where no head shots are allowed at all. Three points will be awarded for a win and one point for a draw, the competitor with the most points at the end of the season will be declared the winner.

Match Area

• All matches will be held within a minimum of a six-meter matted square, called the 'fighting area'. This area is surrounded by a one-meter safety zone.

Fight Wear

- Gi, wrestling singlet, suitable vest and shorts (tight fitting), or any combination of these.
- T-shirts NOT permitted.
- Bare top permitted.
- Wrestling boots, trainers and martial arts shoes not permitted.

Compulsory Safety Equipment

- League Fights: gum shield, groin guard, gloves, and shin & instep pads.
- Gloves: Harbinger, Viper, Rogue and most Mixed-Martial Arts specific gloves.
- Shin & instep pads: Viper and most styles of soft shin pad suitable for Mixed-Martial Arts. A combination of semi-contact foot pads with shin pads will be allowed. Shin pads that include any form of plastic or metal fastening will not be permitted.
- Optional Equipment: Kneepads

Match Duration

• All matches are 1 x 5 minute round.

Ways to Win

- You can win a match by:
 - 1. Forcing your opponent to submit (to tap-out), or to quit.
 - 2. The referee stopping the match or disqualifying your opponent.
 - 3. By knock-out or technical knock out.

Weight Categories

- Men
 - o 60 KG Strawweight
 - o 65 KG Flyweight
 - o 70 KG Lightweight
 - o 75 KG Super Lightweight
 - o 80 KG Welterweight
 - o 85 KG Middleweight
 - o 90 KG Super Middleweight
 - 0 95 KG Light Heavyweight
 - o 95+ KG Heavyweight
- Women
 - o 60 KG Lightweight

Legal Techniques

- Standing
 - All punching and kicking techniques to the body or legs.
 - All knee strikes to the body or legs.
 - o All throws & takedowns.

• On the ground

- Punches and knees to the body only.
- o All permitted submissions.

Restarts

- The match will be restarted in the case of the following
 - Competitors are in danger of leaving the matted area
 - The referee needs to check a cut
 - The referee needs to re-position or replace safety equipment
- In the case of this type of a restart the fighters will be restarted in the same basic strategic position in the center of the area.
- If there is a restart due to a prolonged lack of action from grounded fighters, the fighters will be restarted standing.

Illegal Techniques

- 1. No hair-pulling, biting, eye gouging, head-butting, ear pulling or fish-hooking.
- 2. No elbow strikes permitted.
- 3. No manipulation of small joints (fingers, toes).
- 4. No striking directly to joints.
- 5. No holding of gloves or other safety equipment.
- 6. No heel-hooking or any other technique that places a twisting motion on the ankle or knee joint.
- 7. No standing submission attempts
- 8. No pulling of clothing permitted except to opponent's belt, or to opponents wearing GI's.
- 9. No striking directly to spine.
- 10. No neck cranking attacks such as Can-opener, Crucifix etc.
- 11. No groin strikes permitted.

- 12. Striking not permitted for fighters at different levels (e.g., one grounded, one standing).
- 13. Directly attacking the nose is not permitted.
- 14. Any technique which results in, or is liable to result in, your opponent being spiked (dropped directly on to his/her head).
- 15. Throat strikes of any kind, including without limitation, grabbing the trachea or clavicle.
- 16. Clawing, pinching or twisting the flesh.
- 17. Kicking to the kidney with the heel.
- 18. Throwing the competitor out of the fighting area.

Rules

- 1. All league matches that go the full 5 minutes will be classified as a draw there is no judge's decision.
- 2. All matches are full-contact.
- 3. The referee can warn or disqualify any competitor for disobeying the rules.
- 4. If a fighter is not intelligently defending himself then the referee will stop the match.
- 5. The referee's instructions must be adhered to and his or her decisions are final.
- 6. Gum Shields must remain in the mouth at all times. The referee may pause the action to replace gum shields that have fallen from a competitor's mouth.
- 7. Safety equipment must remain properly attached to the body. The referee can pause the action for required adjustment of any safety equipment.
- 8. A fighter is classed as 'grounded' if any part of their body, except for the soles of the feet, comes into contact with the mat.
- 9. Fighters must remain within the fighting area. Failure to do so could result in a warning for standing fighters or a re-start for grounded fighters.
- 10. The referee can stand grounded fighters if there is a prolonged 'lack of action' on the ground.
- 11. One coach is allowed in the fighting area. Coaches must keep outside the matted area.
- 12. All competitors are expected to behave in a 'sportsman-like' manner.

- 13. Competitors who wish to retire at any stage must communicate this to the competition host.
- 14. No oils (including Vaseline) may be applied to any part of the body.

Competitors Disallowed Entry

In the interest of maintaining safety and fairness within amateur competition, competitors who have fought in two or more 'professional' Mixed-Martial Arts bouts within the last twelve months will not be permitted to compete in League matches. For the sake of this rule, the term 'professional bout' will be deemed to describe a bout in which head strikes are permitted both whilst standing AND on the ground. Amateur' bouts (head strikes permitted standing but not whilst on the ground) are not considered as a 'professional bout' for the sake of this exclusion.
APPENDIX C: INITIAL LIST OF TERMS IN MIXED MARTIAL ARTS

Term	Definition	Used in	Syntactic	Source
		Field	Туре	
Achilles	A popular submission foot	Submission	Noun	Ground
Lock	lock/hold that can take many	Wrestling,		and
	variations, but is ultimately	Sambo		Pound
	dependent on manipulating			
	and applying pressure on the			
	heel and Achilles tendon.			
Amateur	A person who engages in	MMA	Noun	ELITE
	some MMA for the pleasure			MMA
	of it rather than for money; a			
	nonprofessional; specifically,			
	a fighter who is forbidden by			
	rule to profit from athletic			
	activity			
Ammy	Abbreviation for Amateur.	MMA	Noun	ELITE
				MMA
Arm-bar	Otherwise known as the cross	Judo,	Noun	Ground
	lock, an arm-bar is a joint	Submission		and
	lock that hyper-extends the	Wrestling,		Pound
	elbow joint. Most often you	BJJ, Sambo		
	will see it applied as follows:			
	Your opponents arm is			
	trapped between your legs			
	and you hold it either by the			
	hand or the wrist with both of			
	your own hands. You apply			
	pressure by stretching out			
	your body, pressing against			

	his body with your legs,			
	which can be intertwined at			
	the ankles, using his upper			
	body and your groin to			
	increase leverage.			
Americana	Similar to the keylock and	BJJ	Noun	Ground
	kimura is the Americana.			and
	This move involves creating a			Pound
	triangle with your opponents			
	arm and your own. With your			
	opponents arm bent at the			
	elbow, palm up, near or			
	above his head, your arm			
	goes underneath from the			
	bottom and grabs his wrist,			
	'painting' downwards.			
Anaconda	Otherwise known as an arm	BJJ	Noun	Ground
choke	triangle, the anaconda choke			and
	consists of trapping one of			Pound
	your opponent's arms with an			
	underhook and clasping			
	hands on the other side of his			
	neck, squeezing his neck and			
	arm together to cut off air			
	supply. It is most effective			
	when you are on top of your			
	opponent to the side of his			
	trapped arm, with the reverse			
	being called the D'Arce			
	(Dark) choke.			
Athlete	Any fighter, competitor, or	ALL	Noun	ELITE
	participant.			MMA
Back control	Your opponent is sitting on or	BJJ	Noun	Ground

	straddling your back. When			and
	his legs are wrapped around			Pound
	you, especially with them			
	tangled between your legs			
	and locked at the feet, this is			
	called "having hooks in". He			
	can also perform a body			
	triangle by folding the back			
	of his knee over the other leg,			
	cinching tightly to restrict			
	your breathing			
BJJ	Abbreviation for Brazilian	BJJ	Acronym	ELITE
	Jiu-Jitsu.			MMA
Body Slam	When one fighter picks up the	Submission	Noun	Ground
	other fighter and throws them	Wrestling		and
	to the ground.			Pound
Bout	A contest between	Boxing,	Noun	ELITE
	antagonists; e.g. an MMA	Wrestling		MMA
	match			
Boxing	A traditionally western	Boxing	Noun	Ground
	sport/fighting style, boxing is			and
	dependant on using quick			Pound
	footwork, evasive head			
	movement, and accurate			
	punches. Although not			
	considered a formal martial			
	art, boxing's			
	offensive/defensive			
	techniques and real-world			
	effectiveness are an			
	invaluable part of a mixed			
1				

Brazilian Jiu-	A predominantly ground	BJJ	Noun	Ground
Jitsu	oriented martial art, which			and
	was originally derived from			Pound
	traditional Japanese Jiu-Jitsu			
	and Judo. Introduced by the			
	Gracie family of Brazil,			
	Brazilian Jiu-Jitsu's			
	popularity has spread due to			
	its success in mixed martial			
	arts contests. The art is			
	heavily based around the			
	development of numerous			
	submission holds (mainly			
	chokes and arm-bars), but			
	emphasis is also placed on			
	gaining and maintaining			
	advantageous positions			
Butterfly	full guard, but your feet are	BJJ	Noun	Ground
guard	planted on your opponents			and
	thighs, preventing him from			Pound
	posturing up and getting past			
	your guard into a more			
	dominant position			
Cage	A fenced in ring, usually in	MMA	Noun	Warrior
	the shape of an octagon, in			Pages
	which mixed martial artists			
	compete.			
Can-opener	virtually the only submission	Submission	Noun	Ground
	that can be applied in your	Wrestling,		and
	opponent's guard, a can-	Sambo		Pound
	opener entails putting both of			
	your hands behind his neck as			
	with the Thai plum, and			

	pulling his head towards you.			
	This submission is usually			
	applied to open your			
	opponent's closed guard,			
	though it can lead to a			
	submission against an			
	injured, tired, or			
	inexperienced fighter.			
Catch	A form of wrestling that	Submission	Noun	Ground
Wrestling	incorporates submission	Wrestling		and
	holds and tends to favor			Pound
	"catching" an opponents limb			
	for the submission over			
	gaining dominant position			
Choke	A constricting hold applied to	Judo,	Noun	Ground
	the neck in order to restrict	Submission		and
	blood flow to the brain and/or	Wrestling,		Pound
	inhibits normal breathing.	BJJ, Sambo		
	Prolonged application may			
	result in unconsciousness or			
	death.			
Choke Out	When a fighter is choked	MMA	Verb	Warrior
	until he loses consciousness			Pages
Clinch	A position in which two	Thai	Noun	Ground
	fighters are face to face,	Boxing		and
	usually with their arms and			Pound
	upper body locked,			
	performed either for a			
	"breather" or to protect			
	against strikes. Some fighters,			
	such as Wanderlei Silva, have			
	mastered the art of the clinch			
	for offensive purposes,			

	throwing effective short			
	punches and/or knees and			
	elbows from this position			
Clinch	Clinch maulers typically	MMA	Noun	Ground
Maulers	utilize the clinch to stifle an			and
	opponent's strikes and tire			Pound
	them out. In the process,			
	these Maulers will strike with			
	"dirty boxing," knees and			
	elbows, and possibly go for			
	upper body takedowns similar			
	to Greco Roman wrestling.			
	Clinch maulers tend to			
	employ a combination of			
	underhooks and the Thai			
	clinch, which have been			
	tweaked to be more effective			
	in MMA style competition.			
	Several Greco Roman			
	wrestlers have found success			
	with this style, thanks in part			
	to their background in the			
	extremely taxing style of			
	wrestling. Popular clinch			
	maulers are Anderson Silva			
	and Randy Couture.			
Closed Guard	When a fighter holds an	BJJ	Noun	Ground
	opponent in his guard by			and
	interlocking his feet behind			Pound
	the opponent.			
Collar tie	Grasping the back of your	Wrestling	Noun	Ground
(single/doubl	opponents neck; a double			and
e)	collar tie, otherwise known as			Pound

	a Thai clinch or plum,			
	involved clasping your hands			
	together behind your			
	opponents trapezius muscle.			
	Where your opponents head			
	goes, his body follows,			
	making the double collar tie a			
	valuable grappling hold. A			
	double collar tie is especially			
	useful in pulling your			
	opponents head down for			
	knee strikes, effectively			
	doubling the force of the			
	knee.			
Commission	Any recognized state,	Boxing,	Noun	ELITE
	provincial, tribal or city	Wrestling		MMA
	authority designated by state			
	law to oversee and administer			
	all combative sports within			
	their respective jurisdictions.			
Corner	A fighter's "corner" is the	Boxing	Noun	Ground
	section outside of the ring			and
	occupied by individual who			Pound
	will assist the fighter during			
	the bout. A fighter's corner			
	usually consists of the			
	fighter's trainer, training			
	partners, a cutman, and			
	potentially other motivators.			
	The fighter's corner is			
	responsible for giving a			
	fighter advice during the			
	fight, and fixing a fighter up			

	during rounds. If a cut or			
	other injury is sustained			
	during the bout, it is the			
	responsibility of the corner-			
	men to fix it up to the best of			
	their abilities.			
Corner	Individuals who assist and	Boxing	Noun	ELITE
personnel	advise the MMA fighter			MMA
	during an event; individuals			
	who are in the fighter's			
	"corner".			
Crackhead	BJJ legend Eddie Bravo calls	BJJ	Noun	Ground
control	mission control with two			and
	hands instead of one			Pound
	crackhead control. Many of			
	these names are deliberately			
	bizarre so they can be called			
	out by coaches during a BJJ			
	match without the opponent			
	recognizing them.			
Crucifix	from side control you pull	Submission	Noun	Ground
	your opponents arm between	Wrestling,		and
	your legs and cross your legs,	Sambo		Pound
	locking it there, and with one			
	hand you pin down your			
	opponents other arm,			
	allowing your free arm to			
	punch and elbow his			
	unprotected head.			
Cut man	Person responsible for	Boxing	Noun	ELITE
	preventing and treating			MMA
	physical damage to a fighter			
	during the breaks between			

	rounds of a full contact match			
Decision	When a fight goes the full	ALL	Noun	Ground
	allotted time, a group of			and
	judges render what is called a			Pound
	"decision" in order to declare			
	a winner. The decision			
	awarded is based upon a			
	number of criteria, which			
	differs from organization to			
	organization. Most often the			
	greatest factors are			
	effectiveness, damage, ring			
	generalship, and aggression.			
	Decisions can be split (judges			
	select a different winner),			
	unanimous (all judges select			
	the same winner), or draw			
	(judges select no winner, or			
	an even split).			
	The judges' conclusion,	ALL	Noun	ELITE
	declaration, verdict, ruling			MMA
	with respect to the end result			
	of the fight match.			
Dirty Boxing	This is in close boxing from a	MMA	Noun	Warrior
	clenched position. In			Pages
	traditional boxing, fighters			
	would be separated from this			
	position, but in MMA they			
	are allowed to fight from the			
	clench.			
Disqualificati	Preventing someone from	ALL	Noun	ELITE
on	participating in a match by			MMA
	finding them unqualified			

Draw	A fight that ends in a tie; a	ALL	Noun	ELITE
	stalemate: the fight ended in a			MMA
	draw.			
Double Leg	A takedown that is	Wrestling	Noun	Ground
Takedown	accomplished by driving an			and
	opponent up and forward by			Pound
	grabbing both of his legs (or			
	ankles), which leads to both			
	contestants going to the			
	ground. An alternate version			
	is the single leg takedown.			
Escape	Where a fighter escapes from	BJJ, Judo,	Noun	Ground
	a submission or choke hold.	Submission		and
		Wrestling,		Pound
		Wrestling,		
		Sambo		
Event	An organized MMA activity	ALL	Noun	ELITE
	event			MMA
Fish-hooking	The act of "hooking" a finger	MMA	Verb	Ground
	into an opponent's mouth or			and
	ears and pulling, much like a			Pound
	fish on a hook. This move is			
	illegal in all Mixed Martial			
	Arts contests.			
Flattening out	Your opponent can ground	Wrestling	Verb	Ground
	you by taking your back and			and
	then flattening you out. He			Pound
	does so by jumping onto your			
	back and snaking his feet			
	inside your legs and around			
	your thighs. By stretching out			
	his body he is able to spread			

	your legs and put pressure on			
	your upper body, eventually			
	leading you to fall to the mat			
	and possibly lay flat on your			
	stomach with your legs			
	outstretched.			
Flying Knee	A jumping knee strike	Thai-boxing	Noun	Ground
	designed to penetrate the			and
	opponent's defence.			Pound
Forfeit	To surrender; to lose as a	ALL	Noun	ELITE
	forfeit.			MMA
Foul	Not according to the rules of	ALL	Noun	
	a game; unfair, by either			
	accident or intention			
Front Mount	A mount position in which	BJJ	Noun	Ground
	the top fighter is squared to			and
	the bottom fighter with his			Pound
	legs straddling the bottom			
	fighter.			
Full guard	When you are on your back	BJJ	Noun	Ground
	with your opponent between			and
	your legs at waist level,			Pound
	sometimes known as the			
	missionary position. The			
	most important part of this			
	position is holding onto the			
	back of the neck, the wrists,			
	or bear hugging your			
	opponent to control his			
	movement. It is essential to			
	keep him from improving his			
	position because otherwise			

	you will leave yourself open			
	to ground and pound attacks			
	and possibly submission			
	attempts. A "closed" guard			
	means your legs are crossed			
	at the ankles over his back,			
	while "open" means your legs			
	are not entangled.			
Full Mount	The most dangerous position	BJJ	Noun	Ground
	for the bottom fighter to be			and
	in. Your opponent is sitting			Pound
	on your chest straddling you			
	with one leg to each of your			
	sides. Low mount is when he			
	is sitting on your abdomen,			
	high mount when his knees			
	are in your armpits. What			
	makes the position dangerous			
	is that it is difficult to buck			
	your opponent off, roll or			
	sweep him. In the meantime			
	he will likely come down			
	with hammerfists and elbows,			
	or work for a kimura, arm			
	triangle, arm-bar, or choke			
	hold.			
Guard	A Jujitsu term that refers to a	BJJ	Noun	Ground
	specific ground position.			and
	Although there are many			Pound
	variations, the most common			
	version of the guard occurs			
	when the fighter on the			
	bottom wraps their legs			

	around the opponent. This			
	technique is used to			
	simultaneously defend			
	against strikes while setting			
	up a sweep or submission.			
Guard Pass	A technique used by one	BJJ	Noun	Ground
	fighter in another fighter's			and
	guard to move into a mount			Pound
	position.			
Grappling	A general term used to	Wrestling,	Noun	Ground
	describe wrestling and ground	Submission		and
	oriented martial arts.	Wrestling		Pound
Ground &	This is a strategy first	MMA	Noun	Warrior
Pound	employed by wrestlers with			Pages
	limited submission skills. It			
	consists of taking a fighter to			
	the ground, placing them in			
	an inferior position, and			
	striking them until they are			
	knocked out, tap out, can be			
	submitted or the match is			
	stopped.			
	This style is favoured by	MMA	Noun	Ground
	many wrestling-based			and
	fighters, and the basic			Pound
	strategy is to get the fight to			
	the ground, be on top, and			
	grind away with strikes from			
	a dominant position. Due to a			
	wrestler's natural affinity for			
	takedowns, this style is			

	popular with them. Elbows,			
	short punches, and sometimes			
	knees are all deadly weapons			
	when rained down from the			
	top position. Popular ground			
	and pound fighters include			
	Jake Shields, Quinton "			
	Rampage" Jackson, and			
	Fedor Emelianenko.			
Gogoplata	From wikipedia: "it is usually	BJJ	Noun	Ground
	executed from a rubber guard,			and
	where the legs are held very			Pound
	high, against the opponent's			
	upper back. The fighter then			
	slips one foot in front of the			
	opponent's head and under his			
	chin, locks his hands behind			
	the opponent's head, and			
	chokes the opponent by			
	pressing his shin or instep			
	against the opponent's			
	trachea."			
Guillotine	the opposite of the RNC is	BJJ,	Noun	Ground
choke	the guillotine choke. In this	Submission		and
	manoeuvre, you are facing	Wrestling,		Pound
	your opponent and you have	Sambo		
	your opponent in a headlock			
	standing or on the ground			
	with hands clasped together.			
	The choke can be applied			
	more effectively by pulling			
	down on the head while			

	squeezing. Advanced			
	practitioners are able to apply			
	this choke from guard (on			
	your back) or from mount			
	(sitting on your opponent).			
Half guard	similar to full guard, but your	BJJ	Noun	Ground
	opponent has one leg to your			and
	side, with the other between			Pound
	your legs			
Head Butt	To strike an opponent using	General	Noun	Ground
	the head. This move is illegal			and
	in all Mixed Martial Arts			Pound
	contests, but was legal in			
	"old-school" Vale Tudo			
	(anything goes) events in			
	Brazil.			
Headlock	wrapping one arm around the	BJJ, Judo,	Noun	Ground
	neck of your opponent and	Submission		and
	holding his head between	Wrestling,		Pound
	your side and arm. By	Wrestling,		
	grabbing your other hand you	Sambo		
	can tighten the lock, possibly			
	can tighten the lock, possibly achieving a blood or air			
	can tighten the lock, possibly achieving a blood or air choke. On the mat a headlock			
	can tighten the lock, possibly achieving a blood or air choke. On the mat a headlock can turn into a guillotine			
	can tighten the lock, possibly achieving a blood or air choke. On the mat a headlock can turn into a guillotine choke either from your back			
	can tighten the lock, possibly achieving a blood or air choke. On the mat a headlock can turn into a guillotine choke either from your back or in the mounted position.			
Heel Hook	can tighten the lock, possiblyachieving a blood or airchoke. On the mat a headlockcan turn into a guillotinechoke either from your backor in the mounted position.A popular and dangerous	Submission	Noun	Ground
Heel Hook	can tighten the lock, possibly achieving a blood or air choke. On the mat a headlock can turn into a guillotine choke either from your back or in the mounted position. A popular and dangerous submission hold, which is	Submission Wrestling,	Noun	Ground and
Heel Hook	can tighten the lock, possibly achieving a blood or air choke. On the mat a headlock can turn into a guillotine choke either from your back or in the mounted position. A popular and dangerous submission hold, which is applied on the heel and then	Submission Wrestling, Sambo	Noun	Ground and Pound
Heel Hook	can tighten the lock, possibly achieving a blood or air choke. On the mat a headlock can turn into a guillotine choke either from your back or in the mounted position. A popular and dangerous submission hold, which is applied on the heel and then fully accomplished by	Submission Wrestling, Sambo	Noun	Ground and Pound

	Can cause numerous injuries,			
	including the ripping of			
	various tendons in the legs.			
Hip Throw	A hip throw is a popular Judo	BJJ, Judo,	Noun	Ground
	and Collegiate Style wrestling	Submission		and
	manoeuvre where a	Wrestling,		Pound
	practitioner uses leverage and	Wrestling,		
	balance to throw their	Sambo		
	opponent over their hips. This			
	is done by achieving a lower			
	centre of gravity than the			
	opponent, and getting inside			
	their base. A hip throw is			
	often referred to as an "uchi-			
	mata" by Judo practitioners.			
Hooks In	When a fighter has a rear	BJJ	Noun	Ground
	mount and locks his feet			and
	between the legs of the			Pound
	mounted fighter, he is said to			
	have his "hooks in." This			
	prevents the mounted fighter			
	from turning into his			
	opponent to improve his			
	position.			
Hook Punch	A punch with the arm bent	Boxing	Noun	Ground
	that is thrown across the body			and
	to strike the opponent from			Pound
	the side			
Illegal	Techniques, such as eye	ALL	Noun	
techniques	gouging, crotch striking and			
	so on are considered illegal.			
	An opponent will usually be			

	disqualified for using illegal			
	techniques.			
Jab	A lead hand strike used to	Boxing	Noun	Ground
	stun a fighter			and
				Pound
Judo	A Japanese martial art	Judo	Noun	Ground
	founded in the 19th century.			and
	A derivative of jiu-jitsu, both			Pound
	share some of the same			
	history and techniques,			
	though Judo has been refined			
	as more of a sport (striking is			
	not allowed). Judo			
	emphasizes throws and			
	takedowns.			
Kesa-Gatami	A control position similar to a	Judo	Noun	Ground
	side mount except the top			and
	fighter's body is turned more			Pound
	towards the bottom fighter			
	and the top fighter's arm is			
	wrapped around the bottom			
	fighter's head.			
Keylock	a keylock can apply pressure	BJJ	Noun	Ground
	to the shoulder or elbow of			and
	your opponent, depending on			Pound
	how it is applied. It involves			
	holding the forearm and using			
	it to twist the arm. Depending			
	on the direction the arm is			
	twisted in, the standard			
	keylock can become a reverse			
	keylock.			
Kickboxing	A martial art related to	Kickboxing	Noun	Ground

	western boxing, but			and
	incorporating strikes with the			Pound
	legs. Various styles of			
	kickboxing exist with Muay			
	Thai being among the most			
	popular.			
Kimura	Similar to the keylock is the	Judo, BJJ	Noun	Ground
	kimura, which is a very basic			and
	submission hold that			Pound
	everyone knows. It is simply			
	bending your opponents arm			
	and pulling it in an unnatural			
	direction, putting intense			
	pressure on the elbow or			
	shoulder joint. The hold can			
	be applied from a variety of			
	positions, but is mostly done			
	in side control. The hold is			
	named after the Judoka who			
	originated it.			
КО	An acronym for "knock out,"	Boxing	Acronym	Ground
	a term typically used in			and
	boxing. A KO is the act of a			Pound
	fighter taking a hard strike			
	(usually to the head) and then			
	temporarily losing			
	consciousness			
Kneebar	A submission hold that	Submission	Noun	Ground
	hyper-extends the leg at the	Wrestling,		and
	knee. Similar to an arm-bar,	Sambo		Pound
	but focused on the knee.			

Knock Out	When a fighter is knocked	Boxing	Noun	Warrior
(or KO)	unconscious due to strikes or			Pages
	other impact			
	A victory in MMA in which	Boxing	Noun	ELITE
	one's opponent is unable to			MMA
	rise from the canvas based on			
	the ref's judgement after			
	being knocked down or is			
	judged too injured to			
	continue.			
Lay and Pray	Lay and pray is similar to a	MMA	Noun	Ground
	ground and pound style, but			and
	instead of striking on the			Pound
	floor the fighter utilizes			
	position and smothering			
	techniques to ride out a			
	decision. Many top wrestlers			
	emphasize this style,			
	oftentimes due to their			
	inability to adapt to MMA			
	rules. Many fighters with a			
	double background in			
	wrestling and Jiujitsu employ			
	this style to the fullest, as			
	their dominating ground			
	games are light years ahead			
	of most competitors.			
	"Popular" lay and pray			
	fighters include Ricardo			
	Arona and Sean Sherk.			
Leglock	Submission hold that focuses	Submission	Noun	Ground
	on the leg or ankle. Common	Wrestling		and

	leg locks are the "kneebar",			Pound
	"heel hook" and "achilles			
	lock".			
Liver Shot	A combination between a	Thai-	Noun	Ground
	hook punch and an uppercut	Boxing		and
	thrown to the right side of an			Pound
	opponent designed to strike			
	where the liver is. A very			
	painful punch.			
Mission	Like rubber guard, only you	BJJ	Noun	Ground
control	cross your other hand across			and
	your opponent's back and			Pound
	grab your ankle			
Mixed	Hybrid sport allowing	MMA	Noun	Ground
Martial Arts	participation by all martial art			and
	and hand-to-hand combat			Pound
	styles. As a result,			
	participants must be well			
	rounded in all techniques in			
	order to be successful.			
	Despite an inaccurate			
	perception by the general			
	public, the safety of the			
	fighters is paramount in			
	mixed martial arts events and			
	the sport has proven itself to			
	be much safer for participants			
	than boxing or American			
	football.			
MMA	An abbreviation for Mixed	MMA	Acronym	Warrior
	Martial Arts - A combat sport			Pages
	in which fighters from			
	different martial disciplines			

	compete.			
	Mixed Martial Arts	MMA	Acronym	ELITE
				MMA
Mount	A control position in which	BJJ	Noun	Ground
	one fighter is on top of			and
	another fighter			Pound
Muay Thai	A form of kickboxing	Thai-boxing	Noun	Ground
	originating from Thailand.			and
	Unlike traditional kickboxing,			Pound
	Muay Thai allows low kicks,			
	elbows, and knees in addition			
	to punches.			
No Contest	A common decision after a		Noun	ELITE
	"Close" bout protest. Usually			MMA
	selected if the review shows			
	that there really was no			
	dominating winner of the			
	majority of rounds, or when			
	the bout is too close to call			
	and the Reviewing Officials			
	cannot select a clear winner			
	but the majority agree that the			
	"Announced" winner did not			
	do enough to win the bout.			
No Holds	A once popular term used to	MMA	Noun	Ground
Barred	describe "mixed martial arts"			and
(NHB)	events. Due to the evolution			Pound
	of the sport and			
	implementation of safety			
	rules, the term "no holds			
	barred" is outdated but			
	remains in the jargon among			

	fans.			
North/South	your opponent is chest to	BJJ, Judo,	Noun	Ground
position	chest with you but in reverse,	Wrestling,		and
	with his head facing your feet	Submission		Pound
	and your head facing his feet,	Wrestling,		
	sometimes known as 69. The	Sambo		
	point of this position is that			
	your opponent can try to sink			
	in a choke directly or use a			
	"[alli]gator roll" to get his			
	arms around your neck (and			
	arm).			
Octagon	An octagonal shaped ring on	MMA	Noun	Warrior
	which mixed martial artists			Pages
	compete			
Omaplata	This is a more advanced hold	BJJ	Noun	Ground
	that I'll let wikipedia explain			and
	for me: "by placing one leg			Pound
	under the opponents' armpit			
	and turning 180 degrees in			
	the direction of that leg, [the			
	leg] moves over the back of			
	the opponent and entangles			
	the opponents arm. By			
	controlling the opponent's			
	body and pushing the arm			
	perpendicularly away from			
	the opponents back, pressure			
	can be put on the opponent's			
	shoulder."			
Open Guard	A guard position in which the	BJJ	Noun	Ground
	feet are not interlocked.			and

				Pound
Overhand	A haymaker style punch that	Boxing	Noun	Ground
Punch	swings up and over. It is very			and
	powerful and has been very			Pound
	effective			
Overhooks	putting your arm over your	Wrestling,	Noun	Ground
(single /	opponents arm, typically at	BJJ,		and
double):	elbow level, and holding his	Submission		Pound
	midsection or upper body;	Wrestling,		
	two overhooks is called	Sambo		
	double overhooks and			
	clasping your hands together			
	can lead to a bear hug.			
	Generally, overhooks are less			
	advantageous than			
	underhooks and are primarily			
	used as a defense mechanism			
	against double underhooks.			
Point Penalty	The punishment, handicap, or	MMA	Noun	ELITE
	loss of advantage imposed on			MMA
	a fight opponent or			
	competitor for infraction of a			
	rule. Usually at least one			
	point is removed from			
	opponent's score.			
Pinch grip tie	One of your arms goes under	Wrestling	Noun	Ground
	your opponents' arm, the			and
	other over his shoulder, with			Pound
	both hands clasped together			
	behind his back, also known			
	as the over-under body lock.			
	Both grapplers can achieve			

	this position simultaneously.			
	It is useful for bullrushing			
	and forcing your opponent			
	down onto his back. The			
	over-under position is the			
	same as the pinch grip tie,			
	except without having the			
	hands clasped.			
Position	A generic term for various	BJJ, Judo,	Noun	Ground
	positions that a fight goes	Wrestling,		and
	through. Includes "standing",	Submission		Pound
	"mount," full- and half-	Wrestling,		
	"guard," among many others.	Sambo		
Pulling guard	Jiu-Jitsu fighters are often	BJJ	Noun	Ground
	more comfortable fighting off			and
	of their backs than anywhere			Pound
	else. Sometimes instead of			
	engaging their opponent in a			
	stand-up war, or attempting to			
	take their opponent down and			
	mount them, they pull guard.			
	Pulling guard means to grab			
	onto your opponent and pull			
	him down into your full			
	guard. This is uncommon in			
	MMA as it practically			
	requires cooperation on the			
	part of your opponent to get			
	into this position.			
Rear Mount	A mount position in which	BJJ	Noun	Ground
	the bottom fighter has his			and
	back turned to the top fighter.			Pound

Reversal	When a fighter moves from	BJJ, Judo,	Noun	Ground
	an inferior position to a	Wrestling,		and
	superior position	Submission		Pound
		Wrestling,		
		Sambo		
Reverse	A mount position in which	BJJ	Noun	Ground
Mount	the fighters' heads are facing			and
	in opposite directions. Also			Pound
	known as a North / South			
	mount.			
Rear Naked	A type of choke that is	BJJ, Judo,	Noun	Ground
Choke	applied behind an opponent	Submission		and
	upon capturing his back. A	Wrestling,		Pound
	rear naked choke is one of the	Sambo		
	most advantageous types of			
	chokes as far as positioning.			
Round /	Any of the timed periods of a	Boxing,	Noun	ELITE
Rounds	fight; a round is now	Thai		MMA
	generally limited to three	Boxing		
	minutes for non-			
	championship fights and five			
	minutes for championship			
	fights, with the interval			
	between rounds to one			
	minute.			
Rubber guard	Full guard, but you twist your	BJJ	Noun	Ground
	leg so your foot is facing your			and
	opponent, and you grab your			Pound
	ankle with the hand on the			
	same side, trapping his arm			
	and shoulder between your			
	arm and leg. An effective			
	rubber guard can lead to			

	omaplata and gogoplata			
	submission holds.			
Sambo	A Russian martial art that	Sambo	Noun	Ground
	combines elements of			and
	wrestling and Japanese Judo.			Pound
	Sambo is especially vaunted			
	for its leg submissions. One			
	of the most famous			
	practitioners of Sambo is			
	Fedor Emelianenko.			
Shoot	A term that refers to "real"	MMA	Noun	Ground
Fighting	fights (as opposed to matches			and
	that are "worked" or have a			Pound
	predetermined outcome).			
	"Shoot Fighting" also refers			
	to a hybrid fighting style that			
	incorporates the best elements			
	of other martial arts. One of			
	the most famous fighters to			
	claim "Shoot Fighting" is			
	Ken Shamrock.			
Side mount	Otherwise known as side	BJJ	Noun	Ground
	control, your opponent is			and
	chest to chest with you with			Pound
	both of his legs to one of your			
	sides.			
Single-	in wrestling, a single-leg take	Wrestling	Noun	Ground
/double-leg	down is, simply, grabbing			and
take down	one of your opponents legs at			Pound
	the thigh with both arms and			
	driving forward, knocking			

	him onto his back. The			
	double-leg take down is more			
	effective, with your arms			
	wrapped around both his			
	thighs, pulling his legs			
	together and knocking him			
	over as you drive forward.			
	Lifting while performing this			
	take down can increase			
	effectiveness and also helps			
	to direct your opponent			
	towards where you want to			
	go, be it towards a cage wall			
	or into the middle of the			
	fighting area. Some fighters			
	like to lift their opponent onto			
	their shoulder using the			
	double-leg maneuver and			
	then slam them.Small Joint			
	Manipulation			
	Any variation of submission			
	holds which consist of			
	twisting, popping, or hyper			
	extending a small joint, such			
	as the fingers or toes. Such			
	holds are illegal in all Mixed			
	Martial Arts contests.			
Slick	Slick submission fighters are	MMA	Noun	Ground
Submissions	all about getting the fight to			and
	the ground, and they don't			Pound
	care if they have to pull guard			
	to do it. Most slick			

	submission fighters are just as			
	comfortable off their backs as			
	they are in top position, and			
	they are certainly just as			
	dangerous. Grip control,			
	sneaky submission			
	transitions, and fluid sweeps			
	all play major factors in a			
	slick submission fighter's			
	success. Popular slick			
	submission fighters are Nick			
	Diaz, Rodrigo Nogiuera, and			
	Joe Stevenson.			
Scissor	A takedown where one	Wrestling	Noun	Ground
Takedown	fighter places his legs on			and
	either side of a standing			Pound
	fighter and uses a twisting			
	motion to trip the standing			
	fighter with his legs			
Small Joint	Any variation of submission	MMA	Noun	Ground
Manipulation	holds which consist of			and
	twisting, popping, or hyper-			Pound
	extending a small joint, such			
	as the fingers or toes. Such			
	holds are illegal in most			
	competitions.			
Sprawl	A take down defence where a	Wrestling	Noun	Ground
	fighter spreads his legs away			and
	from the attacking fighter and			Pound
	applies his weight to the			
	fighter's back in an effort to			
	deny access to his legs and			

Sprawl and	Fighters more comfortable	MMA	noun	Ground
Brawl	with striking prefer this style			and
	of fighting. Unlike standard			Pound
	striking styles the fighter			
	must adapt their techniques to			
	actively defend takedowns			
	and avoid the ground game.			
	Due to this many strikers			
	practice short combinations			
	of three strikes or less,			
	usually power shots, as well			
	as takedown counter strikes.			
	Some of these, such as a			
	flying knee or rising kick,			
	result in a KO if a single shot			
	connects. Lately many good			
	wrestlers have learned to			
	strike and used this style			
	effectively, due to their			
	heightened takedown defense.			
	Popular sprawl and brawl			
	fighters are KJ Noons, Chuck			
	Liddell, and generally anyone			
	with professional striking			
	experience.			
Stalling	To come to a standstill; an	ALL	Noun	ELITE
	action that is intended to			MMA
	cause or actually causes			
	delay, such as hanging on			
	one's opponent.			
Stand-up rule	This is where the referee can	MMA	Noun	ELITE
	stand fighters up if it is			MMA
	perceived both are resting on			

	the ground or are not			
	advancing toward a dominant			
	position.			
Straight	A reverse-hand punch that	Boxing	Noun	Ground
Punch	flies straight towards its			and
	target.			Pound
Street	A loose "art" consisting of	General	Noun	Ground
fighting	experience gained by fighting			and
	"on the streets." Unlike other			Pound
	martial arts, street fighting			
	places opponents into realistic			
	fight situations, but also			
	exposes them to unnecessary			
	danger and injury.			
Striking	The act of hitting an opponent	Boxing,	Noun	Ground
	with the arm, hand, elbow,	Thai-boxing		and
	head, foot, leg, knee, or any			Pound
	other appendage			
Submission	When a fighter taps out or	BJJ, Judo,	Noun	Warrior
	verbally concedes the match	Submission		Pages
	due to pain, to avoid injury,	Wrestling,		
	being choked out, or a desire	Sambo		
	to end the match.			
Submission	A choke or joint manipulation	BJJ, Judo,	Noun	Ground
Hold	that is meant to cause an	Submission		and
	opponent to submit or	Wrestling,		Pound
	"tapout."	Sambo		
Submission	A hybrid style of wresting	Submission	Noun	Ground
Wrestling	which has many variations.	Wrestling		and
	This style combines portions			Pound
	of traditional wrestling with			

	submission holds.			
Superman	An overhead punch in which	MMA	Noun	Ground
Punch	the fighter leaps at his			and
	opponent in an attempt to			Pound
	avoid his defense.			
Sweep	A generic Jujitsu technique	BJJ, Judo,	Noun	Ground
	that is used to describe the	Submission		and
	person on bottom switching	Wrestling,		Pound
	positions with the person on	Wrestling,		
	top. This can occur as the	Sambo		
	result of a failed submission			
	attempt, strike, or scramble,			
	but oftentimes an actual			
	technique referred to as a			
	"sweep" is employed.			
Takedown	The act of putting your	BJJ, Judo,	Noun	Ground
	opponent on the ground via	Submission		and
	tackle, sweep, Greco-throw,	Wrestling,		Pound
	or other technique, typically	Wrestling,		
	involving the legs and upper	Sambo		
	body. This is a staple move of			
	Jiu Jitsu and "ground and			
	pound" fighters, as they must			
	get their opponent on the			
	ground in order to maximize			
	their ground-oriented fighting			
	style. Josh Koscheck has			
	some of the best takedowns in			
	the sport of MMA.			
Tap Out	A method in which a fighter	BJJ, Judo,	Noun	Warrior
	submits to his opponent by	Submission		Pages
	tapping his opponent, himself	Wrestling,		MMA

	or the mat. Verbal tap outs	Sambo		Termin
	are also allowed.			ology
				List
	An act of submission or	BJJ, Judo,	Verb	Ground
	"giving up" in which an	Submission		and
	opponent, hopelessly	Wrestling,		Pound
	captured in a submission hold	Sambo		
	or being pummelled by			
	strikes, taps the mat or his			
	opponent in lue of blacking			
	out or risking bodily harm.			
Technical	When a fighter is unable to	Boxing	Noun	Warrior
Knock Out	continue, usually due to			Pages
	injury.			
	A victory won when the	Boxing	Noun	ELITE
	opponent, though not			MMA
	knocked out, is so badly hurt			
	that the referee stops the			
	match.			
ТКО	Abbreviation for Technical	Boxing	Noun	ELITE
	Knock Out			MMA
Throw	There are a variety of throws	BJJ, Judo,	Noun	Ground
	in MMA and martial arts in	Submission		and
	general. The most common is	Wrestling,		Pound
	the hip toss, which is similar	Wrestling,		
	to the trip. You hold onto	Sambo		
	your opponent and step into			
	him, partially putting your			
	back to him while twisting.			
	As you do so you pull your			
	opponent over your			
	outstretched hip, sending him			
	spiraling over your			

	midsection and onto the			
	ground on the other side of			
	your leg. Advanced			
	practitioners don't let go of			
	their opponent during his			
	motion and can transition			
	seamlessly into an arm-bar or			
	another similar submission			
	position. Some MMA fighters			
	utilize Judo throws, but the			
	issue with Judo in MMA,			
	similar to Jiu-Jitsu, is that the			
	gi is not permitted. Many			
	Judo and Jiu-Jitsu techniques			
	rely on being able to grab			
	onto your own gi or your			
	opponents. Some fighters			
	have trained in these			
	disciplines extensively			
	without gi's in order to			
	overcome that obstacle.			
	A Judo fighting technique of	Judo	Noun	ELITE
	"throwing" one's opponent to			MMA
	the ground.			
Toe hold	like the heel hook, but with a	Submission	Noun	Ground
	focus on the foot and ankle,	Wrestling,		and
	directly twisting the foot by	Sambo		Pound
	holding it with one hand at			
	the toes and the other at the			
	Achilles tendon			
Triangle	you'll usually see the triangle	BJJ, Judo,	Noun	Ground
choke	choke applied from guard,	Submission		and

	where the man on the bottom	Wrestling,		Pound
	traps his opponents head and	Sambo		
	one arm between his legs,			
	with one leg tightly			
	overlapping and trapping the			
	other at the back of the knee.			
	One or both of the hands can			
	be used to pull down on the			
	head of the opponent locked			
	in the hold to increase			
	pressure.			
Trip	the most common trip you	BJJ, Judo,	Noun	Ground
	will see occurs when your	Submission		and
	opponent has you in a body	Wrestling,		Pound
	lock. He will step forward,	Wrestling,		
	putting his front leg behind	Sambo		
	your leg, and trip you up with			
	it, sending you falling			
	backwards with him chest-to-			
	chest while you tumble.			
	Sometimes your opponent			
	will fall forward in order to			
	ensure you will trip over his			
	outstretched leg and foot.			
Twister	A cross between side control	BJJ	Noun	Ground
	and half guard, twister			and
	involves facing your			Pound
	opponents feet while in half			
	guard, putting your hand on			
	your opponents knee and			
	creating space to spin into full			
	mount.			

Underhooks	putting your arm underneath	BJJ, Judo,	Noun	Ground
(single /	your opponents arm and	Submission		and
double)	holding his midsection or	Wrestling,		Pound
	upper body; two underhooks	Wrestling,		
	is called double underhooks	Sambo		
	and clasping your hands			
	together behind your			
	opponent's back is called a			
	body lock. Using double			
	underhooks enables you to			
	maneuver your opponent and			
	possibly slam him.			
UMMAR	Unified Mixed Martial Arts	MMA	Acronym	ELITE
	Rules.			MMA
Upa	A roll in which a mounted	BJJ	Noun	Ground
	fighter reverses position			and
	ending in the guard of the			Pound
	other fighter.			
Uppercut	A bent-arm punch where the	Boxing	Noun	Ground
Punch	punch is thrown straight up.			and
				Pound
Vale Tudo	Portuguese for "anything	MMA	Noun	Ground
	goes." This term is made in			and
	reference to the "no holds			Pound
	barred" fighting events that			
	began in Brazil. Vale Tudo			
	events are now illegal in			
	Brazil, for the most part, and			
	are looked upon as a bygone			
	era of our developing sport.			
Wrapping	Hand wraps are worn by	Boxing	Noun	ELITE

	fighters under their MMA			MMA
	gloves in order to provide			
	additional protection and			
	support for their hands,			
	knuckles and wrists.			
Wrestling	An ancient sport that dates	Wrestling	Noun	Ground
	back to the dawn of man.			and
	Contestants use leverage and			Pound
	technique to accomplish			
	takedowns and achieve and			
	maintain advantageous			
	positions. There are many			
	variations and styles of			
	wrestling. Although wrestling			
	is not considered a formal			
	martial art, its techniques for			
	positioning and control on the			
	ground are invaluable in the			
	sport of mixed-martial arts.			
Wild	Wild brawlers employ a bolo-	Boxing,	Noun	Ground
Brawlers	swinging, cage slamming	Thai-		and
	style similar to how you	Boxing		Pound
	would fight in prison or on			
	the street. Their go-for-broke			
	style is usually due to a lack			
	of training, but many wild			
	brawlers fight this way as a			
	matter of choice rather than a			
	consequence. This			
	overwhelming style works to			
	their advantage most times, as			
	opponents can't find a rhythm			
	to counter. Sometimes,			
	usually in the face of a calm			
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	technician, this style falls			
	apart rather easily. Popular			
	wild brawlers include Charles			
	"Krazy Horse" Bennett, Tank			
	Abbot, and Thomas Denny.			
X Guard	It is either a form of the open	BJJ	Noun	Ground
	guard or the half guard,			and
	depending on your point of			Pound
	view. You end up here a lot			
	when you use the butterfly			
	guard, especially when your			
	opponent posts his foot to			
	stop your sweeps			
Zuffa	The parent organization of	MMA	Name	Ground
	the UFC is an American			and
	sports promotion company			Pound
	specializing in the promotion			
	of MMA. It was founded in			
	January 2001 in Las Vegas,			
	Nevada to be the new parent			
	entity behind the Ultimate			
	Fighting Championship by			
	Station Casinos executives			
	Frank Fertitta III and Lorenzo			
	Fertitta, after they purchased			
	the UFC from Semaphore			
	Entertainment Group. The			
	word "Zuffa" is an Italian			
	word, meaning "brawl" or			
	"fight with no rules". Zuffa is			
	headed by the Fertittas and			
	President Dana White.			

APPENDIX D: LIST OF TERMS IN MIXED MARTIAL ARTS GENERATED FROM EXPERIMENTS

Term	Definition	Used in	Syntactic	Used
		Field	Type	
Base	Another word for balance /	BJJ	Noun	ID,C
	stability			W
Block	The act of preventing an	Grappling	Verb	OIM
	opponent from going into a			
	defensive position			
Bottom	A term used at Team Ryano for	Grappling	Noun	TE
Position	the guard position			
Bump	To push an opponent away from	Grappling	Verb	С
	the ground position			
Catch	The act of grabbing	Grappling	Verb	OIM
Flying	Variation of the arm-bar	Grapping/	Noun	TE
Arm- Bar	technique performed from a	MMA		
	standing position			
Ground	Knowledge of grappling	Grapping	Noun	С
Experience				
Hands In	Putting the hands on the	Grappling	Verb	OIM
	opponents chest parallel to the			
	arms			
Harai Goshi	A sweeping hip throw from judo	Judo	Noun	TE
Juji-Gatame	Judo name for the arm-bar	Judo	Noun	C, TE
Kimura	A type of arm lock in Judo	Judo	Noun	TE, C
Knee Ride	A grappling position where the	BJJ,	Noun	OIM
	attacker places a knee low on	Wrestling		
	torso of his opponent. The			
	attackers other leg is extended to			
	the side in order to maintain			
	balance			

One Sided	A grip on the same side of the	Judo	Noun	TE,
Grip	uniform			OIM,
				С
Osoto Gari	A judo throw	Judo	Noun	TE
Standing	When two fighters are standing	Grappling	Noun	TE
Positions	upright			
Step Over	A standing movement in which	Grappling	Noun	TE
Standing	the opponent steps over his			
	opponent in order to get into an			
	arm bar position			
Тор	A term used at Team Ryano for	grappling	Noun	TE
Position	the mount position			
Traditional	Another term that means good	N/A	Verb	OIM,
				С

APPENDIX E: TRANSCRIPTS OF DEMONSTRATIONS

Initial Demonstration of Arm-bar Technique

SME: For this arm-bar... hand on the leg
SME: Good Base
SME: Push the elbow into the armpit
SME: Push the elbow inder
SME: Catch here
SME: Or the collar
SME: Or the collar
SME: Push with the feet
SME: Always with the little finger down and hips up
SME: Through the leg
SME: Good control
SME: Push the elbow in
SME: Hand comes through
SME: And catch

Initial Demonstration of Tai-Otoshi Technique

SME: Okay... the thing with this throw is... good grip on the arm and good hand placement here...

SME: so it's this sort of position... want him on his toes...

SME: My leg is down below his knees here... this hand... I'm not pulling it down, its going out...

SME: okay so watch... step...

SME: okay a small variation of this...

SME: push off...

SME: and on the same side...

Arm-bar Output Input Middle Demonstration

SME: The aim of this is to get a submissionSME: From the knee-ride, he defendsSME: Hand comes underneathSME: Block the headSME: Catch the legSME: Finish it offSME: And keep the leg so he doesn't escape

Tai-Otoshi Output Input Middle Demonstration

SME: The idea of *Tai-Otoshi* is get them to the ground, to finish the fightSME: A couple of waysSME: One side gripSME: Make the spaceSME: And step inSME: Leg across the knee

Arm-bar Commentary

1st Technique

- SME: Sakuraba attacks the Kimura, Randleman rolls to escape.
- SME: Sakuraba goes for the traditional rolling armlock, juji-gatame
- SME: Rolls on his left shoulder
- SME: Finishes it off by bringing his leg over the head.
- SME: Stretching out the arm. Traditional juji-gatame

2nd Technique

SME: Iminari goes for a bad kick, oliver takes him down.

SME: Iminari secures the arm with the legs and keeps the elbow close to his own hip

SME: Good grip on the arm to finish off a traditional arm-barSME: Oliver tries to lift him upSME: Iminari straightens up to finish off the arm-bar

3rd Technique

SME: Some early UFC footage

SME: Early UFC footage, the guy on the bottom, no ground experience, reaches up high straightens out his arm, his opponent on top takes it for a traditional straight armbar juji-gatame

SME: The guy on the bottom makes a mistake and pushes his arms up straight and gives his opponent in the grey shorts the chance for a straight arm-bar and finishes with a traditional juji-gatame

4th Demonstration

SME: The fighter on top takes a good mount position.

SME: Keeps the hands up nice and high at the head

SME: the opponent on the bottom is going bump and escape, as he escapes the top opponent threw the leg over for a traditional jiji-gatame

SME: Secures the arm and the head,

SME: the guy makes a mistake by pushing

SME: traditional rolling juji-gatame

5th Demonstration

SME: Nogiera on the bottom puts on a good triangle on colman

SME: Colman goes to standup but stretches his arm out and gives nogiera the perfect arm-bar

SME: Well watch it again

SME: Nogiera goes for the triangle, ties it up nice and tight.

SME: Colman tries to power his way out of it by standing up which gives nogiera the straight arm

SME: As Colman stands up we will see

SME: Stands up, arm comes out straight and the weight of nogeira on that arm colman has to tap

Tai-Otoshi Commentary

1st Technique

SME: This is a good Tai Otoshi. His opponent is walking straight onto him. His takes grips on the one side not the traditional grips. One side... good sleeve grip and drives him... really good.

2nd Technique

SME: This is a good traditional Tai Otoshi, leg straight accross his opponent. Good control with the grips and drives, pulls with them arms. Really good.

3rd Technique

SME: Really good entry here to Tai Otoshi... very good... gets very low under his opponent, gets his leg out nice and straight. Good momentum with the arms and pulls him right on. Really, really good Tai Otoshi.

4th Technique

SME: Good left handed Tai Otoshi here. He waits for his opponent to attack... as he attacks, puts the foot down and comes right accross, really low, good control with the hands, gets the leg right under the knee. And a really good Tai Otoshi. He waits for his opponent to attack... watch him attacking... attacks.. foot down... right across... very good control with the legs and arms.

5th Technique

SME: Another good Tai Otoshi here. He waits for his oponent to walk onto him... comes right accross... right leg down below the knee and good driving with the sleeve grip. Thats what pulls him onto the throw. Really, really good throw.

Arm-bar Cognitive Walkthrough

SME: Good tight grip with the legs
SME: Put my hands through, catch on my leg
SME: So I can keep good base, good and strong
SME: So I can keep good base, good and strong
SME: I going to put this arm pit under my elbow
SME: Turn his arm like this
SME: Turn his arm like this
SME: This arm is coming through
SME: Catching me trap
SME: Or my collar
SME: I'm going to drive down with my feet
SME: And push towards his head
SME: Soon as the grip breaks off
SME: Back around
SME: Fingers down
SME: Hips up

Tai-Otoshi Cognitive Walkthrough

SME: Tai Otoshi... This time your partner has his legs a small bit closer together

- SME: Stepping and pulling
- SME: this is always the reaction you want... step and pull

SME: like this

SME: big step backwards with this leg here

SME: One... two... three...

APPENDIX E: SAMPLE NOTES

In this section we have a sample of the notes taken by the knowledge engineer. In this example, we look his insights in analysing the arm-bar technique in the initial demonstration.

Italics - denotes non-verbal articulation

Bold - denotes verbal articulation

Red - denotes new term

Blue - existing terms

Brown -denotes analysis

Initial demonstration of technique

Starting in the knee-ride position on the left hand side of the opponents body, the expert under-hooks the arm of his opponent and turns his body 180 degrees to the left hand side of his opponent, putting his left knee on one side of the body and leaving the right leg on over the head. He puts his arms around the arm of his opponent and sits back, straightening the arm and hyper-extending the elbow joint.

In this technique, our SME demonstrated an arm-bar from the knee ride position

The expert and the opponent reset to the knee-ride position, this time the opponent performs a hip escape. The expert under-hooks the arm of his opponent and turns his body 180 degrees to the left hand side of his opponent, putting his left knee on one side of the body and leaving the right leg on over the head. He puts his arms around the arm of his opponent and sits back, straightening the arm and hyper-extending the elbow joint.

In this technique, our SME demonstrated an arm lock from the knee ride position despite the attackers to escape using the hip escape technique.

The expert and the opponent reset to the knee-ride position, the opponent performs a hip escape. The expert under-hooks the arm of his opponent and turns his body 180 degrees to the left hand side of his opponent, putting his left knee on one side of the body and leaving the right leg on over the head. This time he puts his right arm around the arm of his opponent and grabs the leg of the opponent and sits back, straightening the arm and hyper-extending the elbow joint. In this technique, our SME demonstrated an arm lock from the knee ride position despite the attackers to escape using the hip escape technique. This demonstration illustrated a one armed variation in the application of the arm-lock whilst the other arm was controlling the leg in order to prevent the opponent from moving out of the position.

Next the SME moves into the mount position. His opponent pushes the expert away. The expert places his two hands on the chest of his opponent 90 degrees clockwise and pushes up whilst turning his body 90 degrees clockwise to align with the hands. Both of his legs are now parallel with his opponent, the expert sits down and places his arms around the right arm of his opponent and sits back, straightening the arm and hyper-extending the elbow joint.

In this technique, our SME demonstrated an arm lock from the mount position whilst the opponent attempts to push the expert from the mount position.

The SME moves back into the mount position. His opponent pushes the expert away. The expert places his two hands on the chest of his opponent 90 degrees clockwise and pushes up whilst turning his body 90 degrees clockwise to align with the hands. Both of his legs are now parallel with his opponent, the expert sits down and places his arms around the right arm of his opponent and sits back, straightening the arm and hyper-extending the elbow joint.

The SME repeats the arm lock from the mount demonstration.

The expert moves in to the guard position. The expert pulls his opponents right arm across his body with his right arm, grabs the collar of his opponents gi with his left hand. He places his left foot on his opponents hip (on the right hand side) and uses the pushing motion to turn his body 90 degrees anti-clockwise. He then lifts his right leg to his opponents shoulder and lifts his left leg over his opponents head. The expert then straightens his leg, which makes his opponent fall to their right hand side. The expert then places his arms around the arm of his opponent and sits back, straightening the arm and hyper-extending the elbow joint.

The SME demonstrates an arm lock from the guard position using the opponent's gi to work against him.

Once again, the expert moves in to the guard position. The expert pulls his opponents right arm across his body with his right arm. He places his left foot on his opponents hip (on the right hand side) and uses the pushing motion to turn his body 90 degrees

anti-clockwise. He then lifts his right leg to his opponents shoulder and lifts his left leg over his opponents head. The expert then straightens his leg, which makes his opponent fall to their right hand side. The expert then places his arms around the arm of his opponent and sits back, straightening the arm and hyper-extending the elbow joint.

The SME demonstrates an arm lock from the guard position, as before but this time does not use the gi to perform the technique.

The expert moves into a seated position where his body is positioned 90 degree anticlockwise from his opponent. The expert's body is upright and his left arm is placed underneath the opponent's right arm. His right arm is placed away from his body.

This is the starting position for the demonstration of the arm-bar. His right is place to give him during the execution of the move.

SME: For this arm-bar... hand on the leg

The expert moves his left hand through the gap in between his opponent's arms and his chest and grabs his leg. The opponent is in a defensive position. He is preventing the application of the arm-bar by holding his right hand wrist with his left hand.

SME: Good Base

The expert moves his right hand behind his body

In getting good base, he establishes good balance so that he can maintain control of his opponent during the execution of the technique.

The SME points to his elbow

SME: Push the elbow into the armpit

The SME push to his opponents elbow into his own armpit

In performing this movement, the expert puts the arm in a position where space is created making it easier in getting his left arm through the gap.

SME: Arm comes under

The experts left arm goes through the gap

SME: Catch here

The expert positions his left hand on his arm.

SME: Or the collar

The expert moves his hand and grabs the collar of his own gi.

The expert demonstrates two ways in which the arm lock can be secured, either without the use of the gi or with the use of the gi. Note: In MMA competition, the application of the arm-bar would be performed without the use of the gi.

SME: Push with the feet

The expert pushes the leg, and shifts his weight to his left hand side. The opponent's grip is broken and he taps. The expert shifts his weight back to the centre whilst holding the arm at the wrist. He takes his left hand off, the wrist and points to the right hand of the opponent.

SME: Always with the little finger down and hips up

The expert demonstrates the hip position by lifting his hips up and straightening his torso.

In this demonstration, the expert demonstrates how to break the grips of the opponent and apply the arm lock. In this he articulated, three rules of thumb. (1) Push with the feet. (2) Always have the finger pointing up. (3) Push the hips up. In his non-verbal articulations, he also identified (4) shifting the weight to the left hand side. (5) Shifting the weight back to the centre. (6) Straightening the torso.

From there he goes straight back into the position the seated position, with hand placed on his leg. He then points to the hand of his leg.

SME: Through the leg

He then places the hand back around to the side

SME: Good control

He then demonstrates that the back of the leg is pushing on the opponent's abdominal section.

SME: Push the elbow in

He then pushes the elbow into his armpit

SME: Hand comes through

The hand goes through the gap created

SME: And catch

His hand is placed on his own shoulder, and shifts his weight to his left hand side. The opponent's grip is broken and he shifts his body back to the centre. The opponent prepares to tap but the hold is released before application of the arm-bar.

The expert demonstrates the techniques once again. This time he makes reference to the need to put weight on the opponent's torso body with the left leg before the elbow is pushed in.

Lessons learnt from the demonstration

- The demonstrations started with three non-verbal demonstrations of strategic knowledge in which the arm-bar could be applied, from the knee-ride position, from the mount position and from the guard position
- In the next phase of the demonstrations, the application of the arm-bar was introduced. Starting from the seated position, the following steps were demonstrated in this order:-
 - 1. The attacker's right hand goes through the gap *in between his opponent's arms and his chest and grabs his leg. (V)*
 - 2. The attacker gets a good base for balance using his left hand (V)
 - Weight is placed on the expert's torso with the left leg (V 2nd demonstration of technique)
 - 4. The attacker pushes the elbow into the armpit with his left hand (V)
 - 5. The left arm comes through the gap created by step 3 and is secured either on the opposite arm or on the attackers own gi. (V)
 - 6. The expert pushes the leg (V) and shifts his weight to his left hand side (NV). This breaks the opponents grip (NV).
 - 7. The expert shifts his weight back to the centre whilst holding the arm at the wrist. (NV)
 - 8. The expert holds the wrist in a position whereby the thumb is pointing upwards (V)

- 9. The attacker then pushes his hips up (V) and straightening his torso (NV) to perform the submission (NV)
- The goal of the technique was not formally established, however in asking to demonstrate the technique it is assumed that the knowledge engineer knows the reason why the technique is used.
- The knowledge captured in the initial demonstration was a combination of verbal and non-verbal articulations.
- In the demonstration of the technique, 8 new terms were introduced. 6 by the knowledge engineer and 2 by the expert. 3 terms were used that were attained in the initial capture of terms. Here is the new terms:-
 - 1. Knee-ride
 - 2. Under-hooks
 - 3. Hip escape
 - 4. Gi
 - 5. Good base
 - 6. Taps
 - 7. Good control
 - 8. Heavy